THE TELEGRAPHIC JOURNAL AND

Electrical Review.

VOL. XVIII.—No. 430.

DYNAMO-ELECTRIC MACHINERY.*

A FEW weeks ago in these columns we briefly surveyed the leading features of the new edition of Professor S. P. Thompson's book on "Dynamo-Electric Machinery"; but there are many points in this excellent treatise which call for more than a passing notice at our hands. In the second edition, a very successful attempt has been made to write dynamo machines up to date, and a large amount of new matter has been added in the form of new illustrations, extended letter press, and additional appendices. Apparently, no pains have been spared to secure the most reliable information respecting the subject in hand; the technical journals published here and on the Continent have been freely drawn upon, with the result that the book as it stands is crammed full of valuable information from beginning to end. The work now before us is the only one yet published which deals exclusively with dynamo-electric machinery, and, writing specially for students, we think the author is wise in supplementing his theory of the dynamo by a description of the practical methods actually employed in the experimental determinations required for constructing this class of apparatus. On reading through carefully Prof. Thompson's book, the reader does not fail to observe that some portions bear the mark of a later date, as if the author in the present edition viewed the dynamo from a somewhat different standpoint from that taken by him when the first edition was published. This is to be expected in dealing with a subject which has not yet reached complete development, but at the same time the impression remains on the mind of the reader that much of the matter which appeared in the former edition, might have been left out, or should have been modified in the present one, while much of the precious matter that appears in the appendices might have been advantageously incorporated into the text. That future editions of this valuable work will be called for is certain, but we trust in the next edition to see the book re-written from the beginning.

Professor Thompson's remarks on page 29, regarding "idle" wire on the interior surface of the Gramme core have an uncertain ring, and these remarks taken in conjunction with those on page 151, where the advantage in this respect from flat ring armatures is said to be *nil*, provided the total lines of force entering the core are not increased, might puzzle the student not a little. Again, on page 36, the author advises the use of long magnets for dynamos, while all constructors are agreed that the shorter the magnets are, the better is the machine, and they believe that the magnets ought to be made just of a length sufficient to provide the necessary surface for the radiation of heat from the magnetising coils. It must be remembered that the author gives his advice with a specific object in view; but if constructors consider the object attained by long magnets to be of no practical importance, and if the best practice proves that this is the case, then the paragraph referred to ought to be struck out in future editions. Paragraph x on page 37 ought to share the same fate. We are not aware that in any modern dynamo, iron or electro-magnets are placed inside the armature to reinforce the field, and in best forms of machine such devices are quite unnecessary. We would also question Prof. Thompson's opinions regarding the position of the coils on the field-magnet cores. To show the reason for his opinion that the wire should be wound most thickly at the centre of the magnet, the author refers us to fig. 6, p. 9; but a simple bar-magnet where the magnetic curves are mostly completed in air can scarcely be considered analogous to the field of a dynamo in which a large mass of iron nearly bridges over the two poles; and lately it has been proved by Mr. Kapp that the amount of magnetism is quite independent of the position of the coils on the magnet cores provided the ampère turns remain unaltered, a fact which had been hitherto tacitly assumed, if not clearly established.

In describing, on page 42, the different forms of field-magnets, we find the author condemning the practice of heaping on them a large quantity of wire. As a matter of fact, in series machines employed for arc lighting this is done with a purpose; and it is known that with less wire the machine will not work well. It is absolutely necessary for these dynamos to have a characteristic in which the electromotive force rises as the current diminishes, in order that lamps in series may work. A shunt dynamo fulfils the condition, but the cost of the wire and winding for the field-magnets in these machines of high potential is prohibitive. A series dynamo can, however, be made to fulfil the condition within the limits of variation of the working current if a large quantity of wire is piled on the magnets, the characteristic being then one in which the E.M.F. rises with great rapidity, attains a maximum, and falls through the range of working. It is necessary to bring the magnets to saturation before the machine is doing its maximum work. True the E.M.F. might be obtained for the particular working current by much less wire on the magnets, but the heaping up is essential to obtain the falling characteristic.

Coming, now, to the chapters on the various types of dynamos in practical use, we notice a somewhat hasty criticism respecting the most recent type of Siemens machine, for without any definition of what constitutes advancement in dynamo construction, the use of cast iron magnets is unhesitatingly characterised as a retrograde step. The enquiry as to what is really meant by improvement is an important one, and the question can only be decided, in our opinion, by re-

* "Dynamo-Electric Machinery," by Silvanus P. Thompson, D. Sc., B.A. (Second edition.) E. & F. N. Spon, London, 1886.

ference to output, efficiency and first cost, the weight being a mere circumstance which may or may not be a disadvantage, depending upon the conditions under which the machine is to be employed. From many experiments the advantage of wrought over cast iron for magnets has been determined, the results showing that by the employment of the former a gain of from 10 to 25 per cent. is obtained. If two machines of similar dimensions are constructed with this difference, that in one the field magnets are of wrought, while in the other they are of cast iron, provided the armature core is sufficiently large in section to carry the increased field, the wrought iron magnet for the same excitement may yield 25 per cent. more lines of force. At the same time it must be remembered that the effect produced by a wrought iron magnet can be produced by one of cast iron if the cross section is made larger; and thus by a greater weight of iron and copper the same output at the same efficiency can be obtained. The question to be answered is, whether the cast iron or wrought iron machine is the less expensive, and upon this answer will depend that to the further question, whether the modification is an improvement or not. The change from wrought to cast iron may be a step in advance if the machine is less costly, and if advancement means a machine of similar capacity for less money. On the other hand, the modification may prove a retrograde step if the object sought to be attained is a machine of small weight. It is pretty certain that many types of machine can be made cheaper in cast than in wrought iron, especially in the smaller sizes, and we contend that it is impossible to say whether the dynamo ought to be made in wrought iron or in cast iron until it is decided whether cost or weight is the more important feature to be considered. We are told that it is possible to get cast iron on the Continent of very fine magnetic qualities, and it may not be generally known that there is less variation magnetically in samples of cast iron than in wrought. It seems to us that in many instances malleable castings might be employed with advantage for field-magnets.

We agree with Prof. Thompson in his condemnation of parallel groups of magnets, but we take exception to his adverse criticism respecting the pole-pieces of the Siemens machine. On page 161, he condemns the practice of making the pole-pieces thinner than the rest of the magnets, and in another place (page 498), when treating of magnets in which a hollowed space is cut out in the bars for the armature to rotate, he remarks that the shaping of the magnet core to this form must not be regarded as a mere thinning of the magnet, as such thinning would be disadvantageous. We cannot say that we clearly comprehend Prof. Thompson here. A pole-piece on such magnets is useless, and the bars can be thinned to a knife edge at the crown of the armature recess without interfering in the least with the efficiency of the machine or without increasing the resistance of the magnetic circuit, for the very simple reason that the lines of force approaching the armature from each magnet find their way into the armature core before arriving at the point named. It is worth while reminding our readers, *en passant*, that a pole-piece must be considered simply as a continuation of the magnets, its purpose being to give the necessary surface, and to prolong the full section of the magnet into proximity with the armature core. The necessity for a pole-piece is merely incidental to the structure of the machine. In most machines, where the axle runs parallel to the magnets, a pole-piece is absolutely necessary since the lines of force have to be redistributed in a new direction before they enter the armature, but where the axle lies at right angles to the magnet, as in the machine described, no pole-piece is required. As a matter of fact, the magnet in this instance is not thinned down at all, if by the term magnet we mean any section in the magnetic circuit through which lines of force pass, for these lines take the shortest way into the armature, and could not utilise the piece which has been cut out. The recess forms, therefore, a virtual pole-piece, no part of the magnet proper having been sacrificed in the thinning down. It is possible that this impression is identical with the one which Prof. Thompson seeks in his remarks to convey.

From the partially historical character of the book, it is probably necessary for the purpose of illustrating the evolution of the dynamo to publish the figs. on pp. 172, 206, and 207; but we think it would be well in future editions to keep those dynamos of the past, which have only a historical value, apart from those of modern type. As it is now, we find the Elphinstone-Vincent machine, an obsolete form, coming after the best modern designs, and a student reading the work through, had he no other guide, would feel uncertain as to which machine was the more important. Again, on page 213, we have the Lontin machine coming between the machines of Gordon and Ferranti, the former being obsolete, and the last two of modern build.

Passing on to Chapter XII., from whence Prof. Thompson develops his algebraic theory of the dynamo, we are met by a somewhat alarming array of symbols. In the formulæ given, as in most formulæ dealing with dynamos, there are too many coefficients, and it is not too much to say that a student with Thompson's book in hand would feel difficulty in designing a machine did he rely on that alone for information. We are tempted rather to regard a good deal of the theory set forth in the same light as that in which Prof. Thompson regards the mathematical labours of Clausius; and the question is, are these formulæ set forth for the purpose of enabling students to construct from their guidance a practical machine, or are they intended simply as a mathematical investigation of the action and reaction going on in a dynamo? If for the latter, then to the mathematician they are extremely interesting, and, from his particular point of view, qualitative symbols have no disadvantages; but if for the former, then we think they fail in the object sought, because the machine has to be constructed before the values of the coefficients can be determined. It is certainly instructive to determine in the laboratory the respective values of "H" and "A"; but the practical designer, degraded, doubtless, he will be thought, cares little what relation the strength of his field bears to the ~~horizontal~~ vertical component of the earth's magnetic intensity. What he wishes to have before designing his machine is some reliable data respecting the number of convolutions and section of iron he must give to his armature. The qualitative formulæ of Thompson, with its armature coefficient and its geometrical coefficient, is useless to him; a quantitative formula is what he wants, and one from which he can obtain his requirements with the least possible trouble. Such a formula is given on page 134, where the E.M.F. of the machine is expressed directly in terms of the area of armature core, convolutions of conductor, and speed of rotation; and having determined from this formula the dimensions of the armature, it only remains for the designer to decide the size of field-magnets necessary for the saturation of the core. In this formula, the product $c.t.a.b$ takes the place of the "A" employed in that of Prof. Thompson; and it is to be remarked that with this substitution all the values are known, since "A" is practically a function of the cross section of armature core. The values of μ have been determined by experiment, and vary from 32 to 38, the exact figures which can be obtained for a given excitement depending on the quality of the iron in the field-magnets and armature, and on the resistance offered by the air spaces between the two. Prof. Thompson's formulæ give us no value of κ, and consequently does not help us to any solution regarding the strength of field produced by a given number of turns of wire on a given section of magnet core.

Recently, Mr. Kapp has given a formula which expresses quantitatively the strength of the field in terms of the exciting current and the resistance of the magnetic circuit; but we understand that the complete expressions which would necessitate the employment of a saturation term have not yet been published, the solution given being only applicable to very small values of exciting current. Whether it is possible to

express by any formula of moderate dimensions the strength of field for all conditions of resistance when this saturation term is included, it is not for us to say, but there is no doubt that such a formula is very much wanted. As it is, the relation between the cross-section of the magnets and the cross-section of the armature varies greatly in different makes of machine, and we regret that no guide on this point is to be found in the work under review. The only part of the armature which should be approximately near saturation is the open part which lies between the horns or edges of the magnet; and although this part has on that account a higher magnetic resistance than the rest of the circuit, yet in armatures of small diameter it represents but a small fraction of the total resistance. Now a field-magnet of section equal to that of the armature core will give sufficient magnetism to saturate the latter; but this means either a very expensive way of producing the magnetism if the core is anywhere near saturation, or a larger armature than necessary if the magnets are not near saturation. This applies to incandescence machines; but for arc machines where the magnets should always be saturated, it would be correct to make the armature core equal in section to the magnets so as to take full advantage of this saturation. We are therefore working under sets of conditions quite different in these two cases, and the rules which apply to one cannot apply to the other. In incandescence machines compounded for constant potential, there ought to be a certain relation of the armature to the field-magnet section which is best, but that this has not been determined yet is obvious from the great differences found in practice. If the armature core is too small, then from its inability to take up additional lines of force save under strong excitement, the series wire will be excessive, while, on the other hand, if the core is made equal in cross-section to the magnets, the electrical resistance of the armature becomes increased along with its weight. The best practice in this class of dynamo consists in making the cross-section of the armature core from ·5 to ·7, that of the magnets.

In considering the relation of size to efficiency (page 271) we fail to follow the author's reasoning. He proposes to make a machine having n times the linear dimensions of an existing machine; it is to have the same number of convolutions on its field magnets and armature, the conductor being therefore n times the diameter of that of the existing machine and of area equal to n^2. Through this machine Prof. Thompson proposes a current of n^3 to flow, but the proposition is surely not a serious one. What becomes of the heat generated in the new machine? Is it realised that with a current of n^3 through $\frac{1}{n}$ resistance the heat generated in the machine is n^5, and that with this heat radiated from a surface of n^2 the rise in temperature will become n^3? There is no reason why the large dynamo should be worked at a higher temperature than the smaller one, and instead of the current being n^3 it ought to be less than n^2, really $n^{\frac{3}{2}}$ if the temperature is to be the same in both machines. Since temperature is the limiting condition, this will materially modify the result given by Thompson; finally it will be found that the work given out by dynamos is about proportional to the weight if the speed is inversely as the linear dimensions, although the efficiency increases with the size.

Passing on to the chapters on self-regulating machines, a supplementary experimental determination for each combination is given, which will be of great value to the student. By the equations the windings are determined on the supposition that the saturation term may be neglected, and a reference is made on page 314 to Dr. Frölich's criticism of the method, the more complicated formulæ of the latter scientist being given in Appendix IV. We are far from suggesting that in future these complicated expressions should be introduced into the text, nevertheless we think it ought to be explained that the present equations give results which can scarcely be considered even as first approximations to the truth.

That the saturation term is really of very great importance may be seen from an example of the actual conditions present in this type of dynamo. In a machine compounded for constant potential, the E.M.F. required to send the current through the armature and series coil may be taken at 5 volts if 100 volts are required at the terminals. If the series wire furnishes half as many ampère turns excitement as the shunt wire we have

$$\frac{5}{100} \times \frac{2}{1} = \cdot 10$$

for the average value of each ampère turn of the series coil as compared with each ampère turn of the shunt, and if we take this example as that of a practical dynamo, the number of turns of series wire given by Thompson's formulæ will have to be multiplied by 10 to obtain the condition of constant potential. This is a rather important error coefficient, and these considerations will show the equations to be not of much use for self-regulating machines, as the solutions they give are not even approximate for dynamos as ordinarily constructed. We question whether it is worth while repeating in future editions the mathematical solutions for constant current, as the construction of machines on such principles involves conditions which are physically impossible.

Following that on compound winding is a chapter on alternating current dynamos, in which is given the latest information regarding this type, and this is followed by a valuable chapter on the coupling together of continuous and alternating current machines.

We recommend students to study most carefully Chap. XX., on the geometrical theory of the dynamo. Engineers are, as a rule, fond of graphic methods of representing facts, and with reason, since a diagram gives at a glance more information than several pages of formulæ, and the "characteristic" of his dynamo is, to the electrical engineer, what the indicator diagram is to the mechanical engineer; the lessons it conveys being fully as valuable.

Having already exceeded the ordinary limits of a review, we shall leave the subject of motors, which is an interesting one, for treatment on a future occasion. In the concluding sections of the work will be found chapters on "The dynamo as a motor," "The theory of electric motors," and "The government of motors," which are amply illustrated by examples of the best forms of apparatus, and which are well deserving of study. A chapter on "Testing dynamos and motors," concludes a work which we have read with pleasure, and of which we shall expect to see many future editions in future years. Written by an earnest student, for students it is in many respects a remarkable book, and in the opinions which we have ventured to express regarding points of difference, our object has been merely to create, in the partial darkness by which some of the solutions are obscured, a few rifts through which in the future a clearer light may shine.

ALTERNATING CURRENTS AND THEIR PART IN ELECTROTECHNICS.*

By MAX DERI.

(*Continued from page* 136.)

IF we had a magnetic-field infinitely extended, and if the magnetic intensity would continually increase from a certain point to another very distant point, we could by moving the turn from the one point to the other point, generate currents in it which have in a certain space of time the same direction. But as this is in reality impracticable, and as motion in a limited magnetic field takes up only a short interval of time, it is clear that in a longer interval of time effects will be

* A paper read before the Elektrotechnische Verein, in Vienna, on the 18th of December, 1885.

obtained in alternate directions, even whether we continue the motion by oscillation, reversing for that purpose its direction, or cause the fields to be repeatedly cut in the same direction.

We shall accordingly obtain nothing but alternating currents. Dynamo-electricity never produces in practice an absolutely continuous current as is generated by galvanic or thermo-electricity.

The currents generated by a dynamo machine, whether a continuous current or an alternating current machine, are then invariably alternating currents which we are, however, able to turn into the same direction. To that purpose serve the commutators or the extremely ingenious collectors introduced by Gramme.

If any one, without regard to construction and the distribution of material, were to assert that an alternating current machine must have less useful effect than a continuous current machine because the currents it produces are alternate, I should retort, That is an error. *Both machines generate alternating currents internally; the quality of the currents only differs in the external circuit of the machine.*

Is there, then, no difference between the two machines? Generally speaking, there is no difference. Any continuous current machine can at once be converted into an alternating current machine, if we only collect the currents as they are generated by the machine. For instance, a Gramme machine, or any other continuous current machine whose collectors are divided in many sectors, produces currents in the same direction if they are led away into the external circuit by means of two brushes which are tangents to the collector in the neutral magnetic zone. If we now join any two sectors diametrically opposite to one another, each to a metal ring and allow the brushes to slide over those rings, the machine will produce alternate currents. It is really a fact that the energy value of those alternating currents is exactly the same as that of the continuous current which was produced by turning the former into the same direction. The internal process remains the same, and that of changing the direction of the alternating current might rather cause a loss than an increase of useful effect.

The difference between machines thus arranged and proper alternating current machines is, that the number of their current or pole reversals is not the same. A Gramme continuous current machine has from 2,000—3,000, and an alternating current machine 6,000 or more reversals per minute. But as at present the continuous current machines are constructed—and that with good results—with two poles, their reversals take place with the same rapidity as in the case of the alternating current machines.

It is also further questioned whether the more rapid current reversals are detrimental to the useful effect of the machine? If the manner in which the machine is constructed should tend to favour the formation of "Foucault" currents, the more rapid reversal of poles would promote that tendency; but, on the other hand, the action of the induction is increased by the more rapid changes of the magnetic fields, the electromotive forces of the armature currents are higher, in consequence of which the internal resistance of the machine, which causes a great loss of energy, can be made lower than in the case of machines with slower reversals. This is borne out by experience.

There is indeed one difference between continuous current and alternating current machines which is decidedly in favour of the latter. The difference lies in the external circuit—the collection of the currents. The continuous current machine must be provided with a commutator or collector from which the currents are sent out, and that is its weak point. The alternate currents are sent into the circuit direct, as they are generated by the machine, either by means of contact rings which make a permanent contact, or—and better still—by means of fixed pole terminals direct from the armature.

It is true that with alternating current machines the objectionable process of turning the currents into one direction cannot be entirely avoided, for those machines require a continuous current for the purpose of exciting their field magnets. At all events the evil is in this case much less than in the case of continuous current machines, both machines yielding the same quantity of current. With a 100 H.P. continuous current machine 600—700 ampères must be turned into the same direction, whilst with a 100 H.P. alternating current machine perhaps only 20—30 ampères are required, the machine generating in both cases a current of an electromotive force of 100 volts.

Hence it is that one is not so restricted in the construction of alternating current machines as in the case of continuous current machines. An Edison 1,000-light machine is regarded as colossal, whilst an alternating current machine for 4,000—8,000 lights is nothing wonderful.

The cause of this is that, with an alternating current machine, the induced coils need not, as in the case of the continuous current machine, be connected to a collector by means of an extraordinary number of connecting wires; on the contrary, the armature coil wires can be easily distributed over the whole circumference of the whole structure in the most suitable manner. The coils can be so arranged as to remain stationary, in order not to expose them to the action of the centrifugal force, whilst the more massive parts of the machine can be caused to rotate instead. Such an arrangement has, down to the present time, been unsuccessfully attempted with continuous current machines.

It is owing to those properties that the alternating current machines require generally less revolutions than continuous current machines. Machines of the latter description making 500 revolutions per minute are rare, whilst for alternating current machines, producing the same effect, half the number of revolutions suffice. There are many such machines that run at 150 and even less revolutions per minute. No one will have a doubt as to the value of this property from a technical point of view.

The alternating current machines have another advantage over the continuous type, which, in my opinion, cannot be valued too highly; the difficulty of generating currents of a high electromotive force, for instance of several thousand volts, with a dynamo machine. Deprez has, with immense trouble, attained in a machine an electromotive force of 3,000—3,500 volts. It is still an open question what effect such a high electromotive force will have on the durability of Deprez's dynamos. I am decidedly of opinion that we shall sooner succeed in leading the thousands of volts safely and without loss through the long circuits than to confine them for any length of time in the armature coils of the dynamo.

In a continuous current armature, which must of necessity form the most compact part of the machine, it is altogether unavoidable that certain points of the current-conveying wires which have considerable differences of potential come in close proximity to one another. The coils themselves are mounted closely together, their connecting wires, and the sectors of the collectors, are still nearer to one another. The danger that, owing to flaws in the insulation, the high potential current "jumps across" is therefore very great.

Deprez has, then, acted judiciously in protecting the field-magnet coils from the high tension by exciting the magnetic fields separately.

Now, all those dangers are in properly constructed alternate current machines reduced to a minimum.

In such machines the armature may be arranged by separate coils in many parts; for instance, a machine with 20 magnetic fields must have at least 20 induced coils in its armature which are completely insulated from one another, and separated by a sensible space. Those coils are joined up in series, for which a single wire, which can easily be insulated and protected, is sufficient. When, for instance, the machine shall generate 6,000 volts, an electromotive force of 300 volts will fall to the share of each coil. It is, of course, very easy to protect the armature wire against the dangers from a tension of 300 volts. By thus distributing the

electromotive force the difficulty can be indefinitely reduced. The field-magnet coils are in no way in connection with the currents of a high electromotive force, but they are circulated by independent currents of a low electromotive force.

To resume, then, I maintain that there is no reason why alternating current machines should not work with as much useful effect, and produce as much energy as continuous current machines. I have even pointed out properties of the former machines which give them great advantages over the latter.

I must remind you that I have been referring, not to the alternating currents, but to the alternating current machines. I will now proceed to consider the alternating currents with regard to their yield and useful effect.

Allow me to return to the subject of induction. I have shown that when a conductor is moved in a magnetic field electric currents are induced, and that those currents are always alternating currents. To this I will add, the induction will be more powerful if the moving conductor is armed with iron (the iron moving along with the conductor) in such a manner as to promote the circulation of the lines of force around it.

But induction currents can be generated without any movement of the bodies at all. I have already pointed out that no energy is expended in the formation of the lines of force, and that the only energy required in the generation of the current is that expended in moving the conductor. But as no current can be produced, without the expense of energy, real work must be expended in exciting the magnet in the case of induction without movement. But in this case the process is of another nature.

In order to illustrate this I will call your attention to the following phenomena, with which you are no doubt familiar. Suppose we have a continuous direct current generated by a constant electromotive force. We lead that current into an electro-motor. If we wish to prevent the armature from rotating, we have only to displace the sliding brushes, so that they are at right angles, to their normal position. The current is now led direct into the apparatus and passes the coils of the armature and of the electro-magnets, producing in them a closed circuit of lines of force.

The strength of the current in this circuit is represented, according to Ohm's law, by the quotient $\frac{\text{electromotive force}}{\text{resistances}}$. This is a magnetisation incapable of doing work, like that which I mentioned previously; the lines of force circulate now in the apparatus, in fact without action or useful effect.

But now I will show you a magnetisation which really consumes energy; which it is, however, able to give back by doing work. If we, without interrupting the circuit, restore the brushes to their normal position, the armature will at once begin to rotate; it will rotate the more rapidly as it experiences the less mechanical resistance. The resistance of the circuit has not been altered at all, and yet the strength of the current does not remain the same. We can see by the measuring apparatus that the current becomes the weaker the more the rapidity of the rotation increases; the rotation of the armature can even stop the current altogether. Such a system will not easily take up magnetic force. We must either oppose resistance to the rotation of the armature, or employ a higher electromotive force; in fact we must do both if we wish to maintain, with continued motion, the same current strength.

In this manner work is, indeed, expended in the formation of the lines of force, and the expense of work thus done is sometimes heavy; but in accordance with the law of the conservation of energy, this work is not lost but can be converted into mechanical energy, if we load the rotating armature with resistances: and this is the fundamental principle of the *electric transmission of power*.

The cause of the phenomenon to which I alluded, we call the *counter electromotive force*, or in this particular case, the counter electromotive force of the rotating armature.

Similar phenomena may occur with alternating currents without rotation or any other kind of motion.

The magnetic lines of force act in a different manner with rapidly changing currents than in the case of continuous currents. The energy of the currents lies in the changes. The lines of force which must change their direction and change their intensity from zero to maximum value a hundred times per second, or still more rapidly, produce in their atmosphere, curves, like those which are formed around the conductor which is being moved backward and forward in a magnetic field; consequently a current is induced in each linear conductor which comes under the influence of the changing lines of force.

The inductive action of the changing lines of force on a wire, a loop, a turn, or a spiral of wire, appears at first as a reaction. Whilst the continuous current always has the same intensity, represented according to Ohm's law by the quotient $\frac{\text{electromotive force}}{\text{resistances of circuit}}$, in the circuit formed by the wire, whether or not iron is present, the alternating currents will give quite different results. It appears that iron, which has been from time immemorial the symbol of rude, lawless violence, can also in this case set aside Ohm's law.

If we place iron—a bundle of iron wires for instance—inside the spirals through which, otherwise, unchangeable alternating currents circulate, the current strength in the circuit, whose resistance has, however, not altered, will sink the lower the more iron is introduced into the spirals. In this case, as in the case of the rotating armature, a counter electromotive force is set up; a peculiar property of the iron impedes the formation of alternating lines of force, and this counter force continues even whilst the iron from which it issues remains at rest; consequently, this counter force depends on the nature of the substance and not on a movement.

You will now see the importance of the changes of the current on the excitement of the magnetism. Whilst we are able to produce an infinite number of lines of force in a very large space by means of the smallest quantity of continuous current, we must expend, more or less, considerable energy, in order to produce magnetic lines of force by means of alternating currents. We only expend work in that mode of exciting magnetism when the energy of the lines of force is also consumed. Simultaneously with the counter electromotive force and parallel to it, a positive electromotive force is set up by the same cause of induction, when a second, a third, &c., linear conductor is brought within the sphere of action of the alternating lines of force.

Two conclusions may be deduced from this property of the alternating currents, namely: 1, that energetic inductive forces can be very easily produced and utilised everywhere by means of alernating currents; 2, that care must be taken that no useless work is done by the inherent energy of the alternating currents.

The counter electromotive force of a spiral through which alternating currents flow, and consequently, also, the electromotive force of a second spiral, depend evidently on the course of the alternations of the currents, and on the nature and the dimensions of the substances in which the lines of force are formed. Iron far exceeds all other substances in susceptibility of magnetic induction. The permeability of iron, that is, its property of conducting magnetic lines of force, is many hundred times greater than that of air. The more iron we use, and the more completely we fill with it the space in which the lines of forces are formed, the shorter they become and the more powerful in their action.

As we have seen that magnet poles can only be formed at those points where the lines of forces enter from the iron into the air, and as we have made the condition, that the lines of force shall not leave the iron at all, but shall circulate and vibrate in that metal, which offers the lowest resistance to them, we must make use of closed iron cores which have no magnet poles.

In order to avoid losses, we must protect all metals that come under the influence of the lines of force, from those parasites which are known to us under the name of "Foucault" currents.

For induction, good conductors—metals—are required; namely, iron for the development of the magnetic lines of force, and copper for the development of the electric currents. The best plan is to use in both cases wires of small section. The iron wires must be mounted in the planes of equal magnetic intensity; that is, in planes which are perpendicular to the current, and the copper wires must be arranged parallel to the current. All wires must be insulated. A system thus arranged will be free from "Foucault" currents, for in it there are no dimensions in which those currents can be formed.

The best and most effective induction apparatus must then fulfil the following conditions: 1. It must allow the unimpeded and easy development of the lines of forces in circles which remain uninterruptedly in the iron; that is, it must have iron cores without poles which form closed magnetic fields; and, 2. The paths of the "Foucault" currents, which tend to develop themselves parallel to the primary current, must be cut off by insulation.

The following example will show the high degree of efficiency of the inductive action of an apparatus constructed in accordance with those principles:

One of our normal transformers* of 10 electrical H.P., or, to speak more correctly, of 7,200 watts effective, have the following resistances in the two spirals:

Primary spiral 1·15 ohms, secondary spiral 0·0045 ohm. In order to produce the above-mentioned normal yield the primary current is of 8·25 ampères, therefore the difference of potential necessary for a continuous current would be $8{\cdot}25 \times 1{\cdot}15$, or less than 10 volts. In reality, 918 volts are required for the purpose of overcoming the counter-electromotive force, when the alternations amount to 100 per second. It is still more striking when the secondary circuit is interrupted; in that case the strength of the primary current is 0·32 ampère. For the continuous current $0{\cdot}32 \times 1{\cdot}15 = 0{\cdot}37$ volt were required, whilst the alternating current requires 900 volts, that is, 2,400-fold the tension of the former.

With the normal yield the primary spiral consumes 7,560 watts, whilst the secondary spiral gives 7,200 watts effective, which represents an efficiency of 95·2 per cent.

When running free, the primary spiral, in consequence of its self-induction, does not consume more than 210 watts, that is, 2·9 per cent. of the normal energy is required to excite the iron.

The internal resistance of the primary spiral amounts to 1·03 per cent, that of the secondary spiral to 0·9 per cent.; the total of the losses: 2·9 per cent. for the magnetisation, 1·9 per cent. for the internal resistances, is 4·8 per cent.

The apparatus contains 80 kilogrammes of iron and 33 kilogrammes of copper. In the former only 210 watts and in the latter only 140 watts are converted into heat, or scarcely $\frac{1}{6}$ heat units per second. Taking into consideration the radiation of heat, it will be seen that such an apparatus becomes very little heated. After having been in full action for several hours, the temperature of the transformer had increased about 25°, so that it might still be touched with the hand.

Where is the dynamo machine which can approach such an apparatus in effectiveness and value? Even the ideal dynamo machine must, when compared with a transformer, still have two disadvantages: 1. The loss due to friction caused by the rotation; and, 2. The dissipation of the lines of force into the air.

How important to the inductive action is the function of the iron will be evident from the fact that the above-mentioned transformer, without its iron core, would work with only 0·96 volt, the secondary current being interrupted, whilst with its iron core it would, under similar circumstances, show an action of 900 volts.

Anyone who is conversant with induction knows how resistances in which the self-induction is neutralised are constructed: the wire being insulated is doubled on itself and then wound in spirals or coiled. The current will flow through the spirals in such a manner that any two neighbouring current elements have always opposite directions. It is immaterial whether a continuous or an alternating current is sent through those spirals, for the real and the apparent resistances remain the same, even when masses of iron are introduced. Those wires are actually without self-induction.

You see, then, that two parallel circuits can exert different inductive actions. If their currents are in the same direction their external actions are added as if the two circuits formed one circuit of double the section. If the two currents are in opposite directions, their united actions only influence the space enclosed between them; externally their actions weaken one another, and that the more the farther the induction has to penetrate.

By this simple and reliable means we can avoid all loss due to induction in circuits. We place two circuits near and parallel to each other; between the two there is nothing but space, therefore no "Foucault" currents can be set up; metals which are situated outside the narrow sphere of action cannot cause losses because the resultant of the inductive action of both currents, even at a moderate distance, has no effect.

I must, however, point out that the inductive action, also without precautionary measures, is usually small, unless considerable masses of iron come accidentally into play, which fulfil the conditions I have previously laid down for an active induction.

By the action of induction the alternating current is greatly superior to the direct current. This action of the alternating current cannot be valued too highly, for it renders *transformation* possible. Is it not of the greatest importance that we are enabled to work with high electromotive forces for conquering distances, and that the high electromotive force, as soon as it becomes troublesome and unmanageable, is at once converted into a low and harmless electromotive force. How much more valuable would not Deprez's results be if he had been able to change his 6,000 volt current into a 100 volt current before leading it into the secondary machine! Can you imagine the possibility of a practical solution of the problem, when the electrical power which is supplied for domestic use, or for industrial purposes in the workshop, has an electromotive force of 6,000 volts?

The alternating current can be employed with equal success as the direct current for the purpose of producing light and heat.

In the case of the production of light—the arc light only—there is some difference in the action. The direct current has here the advantage that it hollows out a crater in the positive electrode which acts as a natural reflector and thus produces a greater illuminating effect; under the circumstances its energy has more useful effect. But, on the other hand, the alternating current has the advantage that both carbons consume at equal rates, hence it is that only that current can be used for Jablochkoff candles, Soleil lamps, &c. For incandescence light both kinds of current answer equally well.

Although the direct current only is at present used for the supply of motive power, it does not follow that the alternating currents are incapable of supplying that power; I even assert that the alternating currents can with useful effect be used for working electromotors, and can also in that respect favourably compete with the direct current. In this assertion I am not merely guided by my individual opinion, but it is also based on results of experiments which are not yet concluded.

Before concluding I must do justice, in one respect, to the direct currents. They possess one property which the alternating currents lack, that is, that the

* The Zipernowski-Déri-Blathy system.

latter cannot do chemical work. Wherever polarity must act a part, the alternating currents are powerless. For electrolysis, that is for all metallurgic purposes, as well as for charging accumulators, they are useless. This particular field belongs exclusively to the direct currents.

But that is the only sphere of action from which the alternating currents are excluded; in all others they will successfully compete with the direct currents.

ON TELEPHONE SYSTEMS.*

By Prof. AMOS E. DOLBEAR.

(*Continued from page* 144.)

BELL'S SYSTEM.

Bell departed from the system already described. Beginning with the transmitter he dispensed with the movable electrodes and the variable resistance, and in the place of that apparatus he placed an electro-magnet with its armature, proposing to speak to the armature itself, which being set in, forced vibrations similar to the originating sound waves, which should react upon the poles of the magnet, and they upon the coils of wire surrounding them, and the current that was maintained in them by a galvanic battery, thus causing electrical waves in the circuit corresponding to the sound waves which produced them. The receiver was another

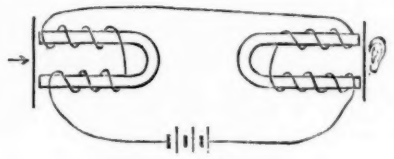


FIG. 5.

electro-magnet similar to the first, but so mounted that the vibrations set up there should reach the ear advantageously. So far as the action at the receiver was concerned, it was similar in all respects to the action in Reis's receiver, nevertheless the whole is deserving the distinction of a separate system, for the receiver now became a transmitter, and thus it had an entirely new function in addition to the old one. *The really new thing about it was the transmitter*, which acted by setting up electromotive forces in the circuit, which reacted upon the electromotive force of the battery, and therefore varied the strength of current in the circuit. The successive steps in this method are: sound vibrations in air causing forced vibrations in the armature of the magnet, varying the strength of the magnetic field. The varying field reacts upon the coil of the electro-magnet, and the current of electricity present in it, setting electromotive forces of a vibratory kind, now in this direction and now in that, according to whether the armature moved towards or away from the poles. The action is one of successive transformations of energy, the source of all the changing electromotive forces being the energy of the sound vibrations themselves, and therefore quite unlike the Reis transmitter, which is simply a controller of the electric energy which is provided by a separate source.

In the Reis transmitter, the strength of the current is varied by mechanical means directly, while in Bell's transmitter the current is varied by magnetic means directly. The contrast is still stronger, for on the one hand the changing currents are really vibratory, to and fro in direction, while in the other the currents are all in one direction, only varying in strength. The one produces its effects by *changing the direction* of its currents, the other by *varying* the strength of a continuous current.

* A Lecture delivered before the Franklin Institute, Friday, December 11th, 1885.

At the receiver, the succession of transformations is similar in each. The magnetic changes produced by the currents result in a varying magnetic field and a corresponding strength of attraction upon the armature, which moves in obedience and vibrates, imparting its energy to the adjacent air. As a matter of fact, the form of the electro-magnet employed for the transmitter was not the same as that used for a receiver. At the Centennial Exhibition of the telephone, the receiver was a cylindrical electro-magnet, the coil being within the cylinder, the armature being a disc that fitted like a cover upon one end of it. This receiver was given to Sir William Thomson, who carried it home with him. During transportation, the armature got bent up to an angle of forty or fifty degrees from its proper position facing the poles. Sir William testified in a London Court, where he showed the receiver with the armature still bent out of place, that he had endeavoured to make it talk after his return home, but had not succeeded, and he could not remember but that the armature was intended to be bent up as he found it on unpacking, so the man who made it was called up to testify what the intention was. I think that anyone less eminent than Sir William, who had been called as an expert, and who should give such testimony as that, would be at once ruled out as incompetent.

In the same year, 1876, I proposed to employ permanent magnets for both receiver and transmitter, so as to dispense with a battery, and have each instrument of the same form. This was before I knew anything as

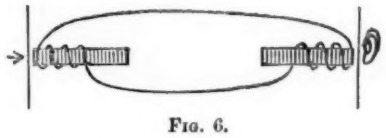


FIG. 6.

to the instruments that Bell had employed, and the first one made was with a straight bar magnet with the coil wound over only one end. This kind was soon found to be much more efficient than the electro-magnet and battery, and was adopted to the exclusion of the other. Considered as a system, however, it differs from Bell's only in this, that in the latter, the generated currents modified the current permanently in the circuit, while in mine the generated currents were the only ones in the circuit. Several electricians have stated that the two are identical, and that the only object of employing a battery was to keep the magnets magnetised, in spite of the well-enough known fact that a magnet may be made stronger by permanent magnetism than by a current on a line of any considerable external resistance, without using an inordinate battery. Somehow I had, for twenty years, the idea of the reciprocal action of magneto-electric devices. I had tried, in 1855, to make one magneto machine run another one, and, failing to do it, wrote to the editor of the *Scientific American* to know why it didn't work. The response was one of two or three lines in the column to correspondents, which answer I have forgotten, for I haven't seen the number since that time. It was marked "A. E. D., Mo.," where I was living at the time. Also, in 1864, I proposed a similar plan for a telegraph, the sender and receiver to be alike, and with similar functions. I mention these in justice to myself and in order to point out that there was nothing that was new to me in such combination of actions.

The system used at present in *legal telephony* consists

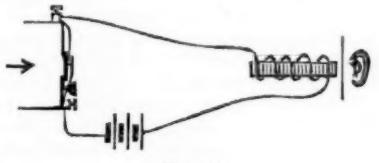


FIG. 7.

of a transmitter of the Reis pattern, and differing from it only in the substitution of hard carbon where Reis

used platinum, while for a receiver is used my straight bar permanent magnet telephone of 1876. It is Reis's system plus a permanent magnet.

BERLINER'S SYSTEM.

Berliner proposed a still more novel plan for a speaking telephone, because it involved principles unlike any of the others. His system consisted of a transmitter similar to the Reis's in principle, and his receiver

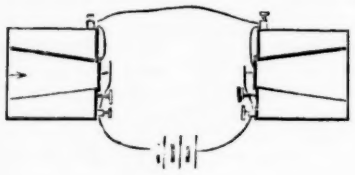


FIG. 8.

was a duplicate of the transmitter. The two similar instruments were to be put in circuit with a suitable battery, when an electric current would traverse the line. Talking to the transmitter would vary the strength of the current, and this varying current would vary the temperature of the electrodes at the receiving instrument enough to develop there what may be called a modified Trevelyan effect, and produce a sound, the character of which would depend upon the varying rate of the electrical energy spent at the terminals. The receiver could then be used as a transmitter, so that, like the Bell system, each instrument had a double function. The Berliner receiver depended upon the convertibility of electricity into heat, the latter at once doing work in moving the diaphragm. This was a highly ingenious plan, and is a system by itself, as much so as any I could name. The same principle has been varied somewhat and improved upon by others. I, myself, in 1878, used the heating effect of the current in a short wire to work a receiver.

Preece, in 1880 or 1881, likewise described some experiments of the same sort; while Cross has lately obtained surprisingly good results by using a platinum wire about six inches long, fixed to the middle of the diaphragm, and a current strong enough to keep the wire red hot. He described the effect to be such that the talking could be heard several inches from the receiver. In my opinion, the transformations of energy are the same in these cases, and I therefore include them under the head of Berliner's system.

EDISON'S SYSTEM.

Ten or twelve years ago, Edison discovered that electricity was competent to lessen the friction between two surfaces, and, at first, adapted the discovery to a telegraphic receiver, and he gave the name Motograph to it. Later, he invented a telephonic transmitter, in which the current traversed a mass of lamp black, fastened between a solid back and a diaphragm, against which sound waves could impinge. The vibrations of

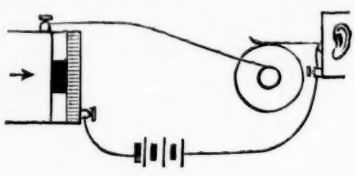


FIG. 9.

the diaphragm changed the conductivity of the parts and so varied the current. It is a variable resistance transmitter, in which lamp black takes the place of the platinum in Reis's transmitter. It was impossible, on account of the mechanical structure, that there could occur a break in the current in Edison's transmitter, and the changes in resistance were sufficiently great to make it excellent for its purpose. Edison then adapted his motograph to telephonic purposes, calling the modification a motophone, when he then possessed a telephonic system which, for loudness of performance, leaves nothing to be desired. It embodied mechanical details in the transmitter that vastly increased its efficiency, and in the receiver there were transformations electrical, chemical and mechanical, such as had not been even known until his discovery. I am very strongly of the opinion that Edison's system is one quite distinct from any other, being radically different from anything found in Reis, or Gray, or Bell.

DOLBEAR'S SYSTEM, NO. 1.

In 1878 I devised what I called a battery transmitter, in which one of the battery plates was so mounted that the sound waves could impinge upon it and cause it to vibrate. In fact, the plate was used for the double function of a battery element and an acoustic diaphragm, the other element of the battery, zinc, being thick and rigid. The cell was thin and small, holding but about a tablespoonful of dilute acid. When this cell was spoken to, the vibrations of the plate were sufficient to give the proper characteristics to the current which the cell itself provided, and speech was rendered in the ordinary receiver with distinctness nearly "sufficient for every one." I also invented a

FIG. 10.

new receiver combining the attraction of a magnet, and the varying friction produced by the varying magnetism. An electro-magnet made with a core which could be rotated on its axis within its coil had resting upon its two poles the two ends of a curved armature, the middle point to which was fastened to the middle of a diaphragm. When a current of electricity traversed the coil, the magnet attracted the armature, holding it snug against the round sides. When now the core was rotated, the adhesion caused the middle of the plate to be bent in or out, as the turning was one way or the other. If the current varied in strength, the magnet varied in strength, the adhesion varied with it, and the armature was thrown into vibrations that corresponded with the current charges, and so speech could be rendered with it. In this it is the varying friction caused by magnetic changes which is the cause of the sounds, not magnetic induction as in Reis, or chemical dissociation as in Edison's, while the transmitter had the double function of both battery and transmitter, and, therefore, in accordance with my method of distinctions, I rightfully call this a system.

DOLBEAR'S SYSTEM, NO. 2.

I once had a receiver so made as to permit a current of electricity to pass between two plates with a few drops of ammonium chloride between them in the expectation that the decomposition effected by the cur-

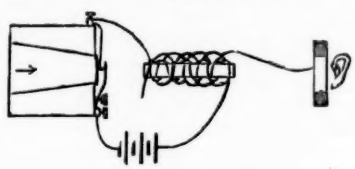


FIG. 11.

rent would result in gaseous products which would move the plates. I found the result I expected, and had a receiver still different in principle from any I have described, in as much as the dissociative chemical relations of the electricity was the immediate cause of the sound vibrations. At one time, while experimenting with this the liquid leaked from between the plates, when I found I still heard the talking plainly. This new phenomenon I at once began to work out towards still better results until the receiver assumed

its present form. For a transmitter, I found it necessary to use the high electromotive force which I could only get from an induction coil. Inasmuch as the receiver consisted of two plates as perfectly insulated from each other as it was possible to make them both by a thin layer of air and by thick varnishing, the resistance was practically infinite, and no current could traverse it; therefore a transmitter such as could only vary a current which must be maintained, was out of the question. An induction coil is an essential part of the apparatus. The complete transmitter consists of the variable resistant transmitter of the plan of Reis, hard carbon being used where Reis used platinum, combined with an induction coil of high resistance, 3,000 ohms or more, the terminals of this coil connected with the two plates of the receiver by the ordinary line wire. The structure of the receiver is such as to constitute it an air condenser, but in addition to that the varnishing upon the plates plays a very important part, an essential part in its commercial working, for it adds to the capacity of the condenser in two ways: (1) As an ordinary dielectric, and (2) in its absorptive property by which it becomes electrified, retaining its charge. It is then like a charged electroscope or electrometer, and is much more sensitive than when the plates are simply metallic and incapable of such electric action. In operation this system is radically different from the others, for (1) it is not operated by a current. The opposed plates are oppositely charged, and therefore attract each other. One of them is free to move slightly towards the other at its middle point, the strength of the attraction determining the amount of movement, but no current traverses the receiver for its resistance is measured by thousands of megohms and Ohm's law has no application to it. (2) The electrical condition of the line is entirely different from that in the other lines, for as no electricity can flow through it, the line itself becomes a charged body, and any electrical changes taking place in it are of the nature of electrostatic phenomena. In the magneto telephone the electricity goes uninterruptedly through the coil to the ground beyond. In the static telephone it comes to an impassable barrier and it accumulates there, it piles up, so to speak, as the tide does against the shore. The line, therefore, may have its electrical condition likened to an ocean tide and a continuous change of level, while the magneto line may be likened to an unobstructed river with variable quantities of water flowing. Prof. Cross who has made measurements of the current strength employed in telephones with various transmitters, reports that there was no measurable current in my line, which is just what I have maintained from the outset must be the case. But there have been some electricians who have declared that so far as the line was concerned there were currents in it just the same as in the common telephone lines. (3) High electromotive force is another essential condition. A battery and a transmitter, however good for magneto purposes, will not work my receiver, for it is the function of the transmitter to vary the current, and if there be no current evidently there can be nothing to vary.

As both transmitter and receiver are necessarily unlike any of the others, and as the transferring line is in a different electrical condition, and the character of the transformations of energy not to be found in the others, it is a system by itself.

FIG. 12.

If two receivers be placed in same circuit uncharged if one attempts to use the arrangement for the transmission of speech he will fail, for merely vibrating one plate near another will not generate an electrical phenomenon, but if the line be charged in any way, one may then use each instrument as transmitter or receiver. In this way I have worked successfully over a half mile of line with the most ordinary insulation.

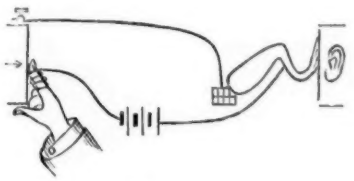


FIG. 13.

(4) In 1878 I found that if an electric circuit was completed through the finger in contact with the bottom of a tin cup, the current on the line would be varied by the change in pressure produced by sound vibrations in the cup, so that it was a variable resistance transmitter. With a dozen gravity cells and the end of the finger moistened it is a tolerably efficient transmitter. The receiver with which I have represented this transmitter in circuit is an ideal receiver which I have threatened to make every summer for six or eight years, but have never done it. Ever since Galvani's experiment with the frog's leg that has been a standard experiment, yet I confess I never witnessed the phenomenon. It is said that the properly prepared leg of a frog is a particularly delicate electroscope, and that it only requires the contact of a piece of zinc and copper to throw the leg into spasms. I therefore proposed to connect such a leg with the plate of a telephone, completing the circuit through the leg, a battery and a transmitter, expecting that the changing currents would cause corresponding muscular movements of the frog's leg which would be communicated to the plate, in which case the diagram represents still another system.

BREGUET SYSTEM.

There is but one other complete system that I chance to know of, and that is Breguet's. Lippmann made the discovery that the surface of mercury was visibly deformed by a current of electricity upon it from the point, and Breguet reduced this to telephonic purposes. Transmitter and receiver are both alike and have

FIG. 14.

similar functions. A glass vessel contains some mercury with some acidulated water upon it. A small glass tube drawn to a point but not closed, is also filled with mercury and properly supported above, so that the point of the tube should be quite near the surface of the mercury. The mercury in both cup and tube must be provided with external metallic connections that an electric circuit may be completed. When these two are connected thus, any motion of either tube towards or away from the surface will be followed by a corresponding motion of the other.

There are several telephone inventions of importance, and some of them of the highest, that are in the nature of improvements. Transmitters and receivers have both been made more efficient by their use, while some have only a scientific and theoretical interest. A few of these I shall notice.

Among transmitters embodying difference in principle I would name the thermo-electric pile. In 1873 I described at the Portland meeting of the American Association for the Advancement of Science, an experiment I had made "On the Convertability of Sound into Electricity," in which the vibration of a tuning

fork upon the face of a thermopile had developed electricity. At the time the criticism on the paper was that the vibration resulted in heat, which was the cause of the phenomenon.

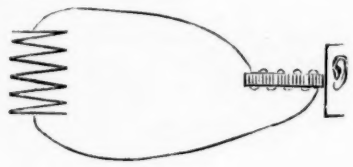


FIG. 15.

As soon as the magneto telephone was available for the test I coupled it in circuit with a thermopile and applied the tuning fork as before, and at once heard the pitch of the fork at the receiver, and that, too, at the distance of half-a-mile from the thermopile. I have also heard the voice, but only very weakly, with a thermo transmitter. The electromotive forces are at best but about ·0001 of a volt, and with such nothing much can be expected. As contrasted with such weak currents an electric arc, half-an-inch long, is at the other extreme.

As the arc is exceedingly sensitive to air currents, and as an arc may be blown out with the breath, it occurred to me that possibly the changes in density in air vibrations made to go through an arc would vary the current strength enough to enable sounds to be

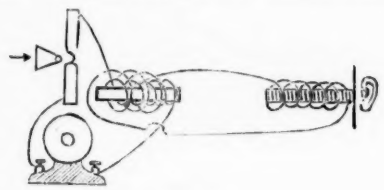


FIG. 16.

reproduced by it. The sounds were directed to the arc by a speaking tube, every word spoken driving the sparks two or three inches away from the arc. The current was passed through the primary wire of a large induction coil that could not be injured by such a current of 15 or 20 ampères. The terminals of the secondary connected alternately with the magneto and the static receivers. Only the faintest show of a sound could be heard. I did, however, hear some sounds, but not speech. Whistling was plainest.

I discovered one thing of interest and of some importance, too, as bearing upon future improvements in transmitters; that is, that the most sudden break of such a current produced an hundred times less sonorous effect in the receiving telephone than the break from a single Leclanché cell would give. The explanation probable is, that it is impossible to produce a sudden enough break to affect the telephone, so that the ear could perceive it. Not that the ordinary effect of magnetisation and demagnetisation are not perceived, but their gradualness prevents an acoustic effect. It was not possible to get a spark of any appreciable length by the breaking of such a current, though with half-a-dozen bichromate cells a spark four or five inches long was easily obtained. As it has been found by experience that an electromotive force greater than three or four volts in the primary circuit with a Blake or other transmitter of that kind was not so efficient as less, I take it to be explained that within the slight movable distances to which the the terminals of such transmitters are subject, the formation of an arc across the space is detrimental to the performance, for if there be an arc the current is not varied, it continues right on with no considerable diminution. It is, therefore, necessary to use a lower electromotive force, and that from two Leclanché cells, say three volts, is as much as can ever be employed with such transmitters.

Elisha Gray discovered a curious electro-physiological phenomenon a good many years ago, that when vibratory high tension currents passed through a finger contact upon a movable metallic surface that there was an apparent increased adhesion, and the metal gave out a sound which was the pitch of the interruption of the circuit. This he modified into a telephonic receiver. The phenomenon is curious when compared with that of the motophone of Edison, for in the latter the friction is lessened by the current, while in the former it is increased.

Lastly, there are three telephonic receivers, which have nothing but novelty to recommend them, but I thought you might like to know of them.

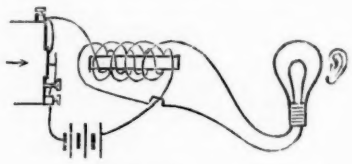


FIG. 17.

(1.) An incandescent electric lamp of the ordinary sort makes a speech receiver. The current needs to be a strong one, and it performs better when the current is sufficient to heat the filament to low redness. I suppose it is to be explained by what I have described under the head of Berliner's system.

(2.) Crooke's tubes may be similarly employed, only a high resistance induction coil is needed. By using one in which the gaseous impacts are against the side of the tube, or bulb, and that held against the ear, one may hear the spoken words.

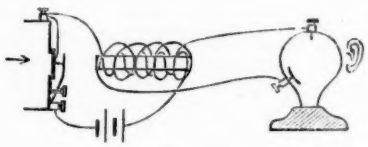


FIG. 18.

3. A Leyden jar of the ordinary pattern held, one hand grasping the outer coating while the knob is placed in the ear, the two coatings being the terminals of a secondary from almost any kind of a transmitter.

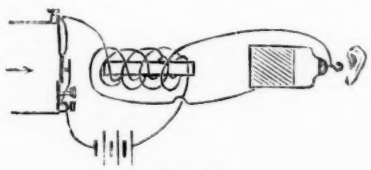


FIG. 19.

It was Hughes, of England, who discovered the great sensitivity of hard carbon and pointed out its adaptability to telephonic purposes. A discovery of such importance, that if he had seen fit to patent, as he might have done, he would have practically controlled the telephone for commercial purposes. The Royal Society of Great Britain has just honoured him for this among other distinctions. It has been claimed by those who own the right to the use of plumbago and lampblack for such uses that they also own hard carbon of any sort, but they are no more to be compared than peat and anthracite.

The properties of a body are not the properties of the atoms of the body, but depend upon the molecular constitution and arrangement of the body. It is the atom that is named carbon. It is the molecular properties that are wanted, and the molecular properties are not the same in lampblack and gas coke. If one should discover that starch could be used for a certain useful purpose, and afterwards some one should discover that cotton would answer very much better, and if the first should then claim the cotton because he first described an amylose for the purpose, the cases would be similar. Yet I heard Sir William Thomson say that it required but an infinitesimal amount of invention to substitute

gas coke for lampblack, and we all know what infinitesimal means to him.

The Blake transmitter consists simply in the adoption of Hughes's hard carbon for the platinum in Reis's transmitter. It makes it much more efficient, but does not change its mode of operation nor vary the mechanical relations.

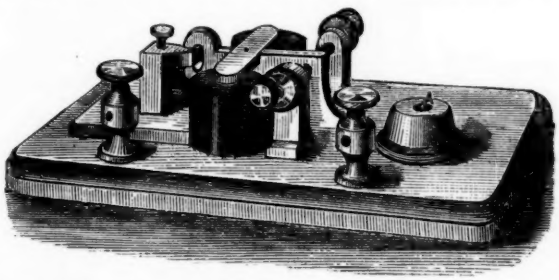
Hunnings, an English clergyman, has made a very useful transmitter by employing granulated hard carbon, arranged mechanically in the circuit as Edison arranged his carbon button, and with this transmitter the best long line work has been done.

In conclusion, I do not pretend to say who was the first inventor of an art of telephony, but I think I have made it plain that there are several arts of telephony that are complete in themselves, just as there are several arts of picture painting. One man paints with a brush, another with a roller and a press. When the pictures are done, no one can tell, by inspection, which way either was made, hence it is improper to speak of *the* art of picture making. Leaving out all that was done before 1876, I submit that the work of that year ought not to control systems that have been invented and discovered in their entirety since that time, and have almost nothing in common with it. I protest against it in the name of law which has been misjudged; I protest against it in the name of equity which has been scandalised; and I protest against it in the name of science, whose eyes are not bandaged as are the eyes of justice, herself a judge, the court of highest appeal, and who writes after every signature to a judgment in her court, *competent* or *incompetent*.

THE SENSOPHONE OR TOUCH-SOUNDER.

THIS instrument, which is patented in the United States and foreign countries, is claimed to be the only one ever perfected by which a telegram can be received by the sense of touch, the patents being owned by the United States Electrical Company, of New York.

By placing the finger upon the touch point, A, according to the description given by our namesake in America, this receiver will deliver the message to the operator by a series of light pricks, caused by a



vibrating needle, being identical with the ticks made by sound. Experts who have tested the instrument affirm that they can receive faster and with greater accuracy than by sound. For those who have learned to read by sound, this instrument offers no obstacle. By removing the finger, the instrument resumes its functions as a sounder; thus the utilisation of two senses are combined. The opening of a new sense in the art of telegraphy offers a field of usefulness to deaf mutes, whose sense of touch is particularly sensitive.

ELECTRIC LOCOMOTION.

By A. RECKENZAUN.

IX.

WE have seen that the maximum current used with one car running upon the tramline (fig. 8, *ante*) was 47·1 ampères; and the average working current during the whole journey amounted to 14·68 ampères. No allowance has been made for the extra effort required in starting the vehicle from rest; in fact, the figures were based on the assumption that the vehicles were kept in continuous motion. We know that this initial current depends upon the resistance of the motor, and if this resistance is, say, 1·6 ohms, then (avoiding artificial resistances) the current flowing at the instant of starting one car will be $\frac{200}{1{\cdot}6 + {\cdot}4} = 100$ amperes. Four cars starting simultaneously would, without inserting artificial resistances, take $\frac{200}{{\cdot}4 + {\cdot}4} = 250$ ampères; and it is doubtful whether four vehicles could start with less than 62·5 ampères each on the more difficult parts of the line before us. The resistance of the generating dynamo is, for economic reasons, very small; consequently, this factor, if introduced, will but little affect the results. It is evident that this dynamo may have to furnish currents varying between 178 and 350 ampères, or even more, and the average energy arrived at in our previous calculations will have to be considerably modified, whilst the maximum power of the steam engine and dynamo must be at least double what may appear to be sufficient to maintain the traffic of 12 cars. The average energy utilised will not be double if the stopping and starting occurs at long intervals, and this will entirely depend on local circumstances; but we believe that for the case under consideration an engine, capable of giving out at any moment and at frequent intervals, a power of at least 150 H.P. may be required, not indicated, but actual brake H.P. when allowing a commercial efficiency of 85 per cent. for the dynamo machine.

If each car stops only twice every mile, then we get a total of 144 stoppages her hour; but this will be considered a very low estimate when compared with the statistics of town traffic, where on an average *seven* passengers are taken up and set down per mile run by each car. At this rate our 12 cars would have 508 stoppages each hour, or one every 7 seconds. This explains the discrepancy between the theoretical or calculated and the actual power employed on electric railways; up to the present day there is no electrically-worked tramway or railway in existence which can boast of more than four cars in continuous use.

The idea of using conductors for electric tramways appears very simple and effective so long as one car only is being propelled, but each additional vehicle brings its difficulties, and the time seems far distant for one to imagine an ordinary street tramway having, say, 30 cars or more in constant use, worked electrically in the manner described above.

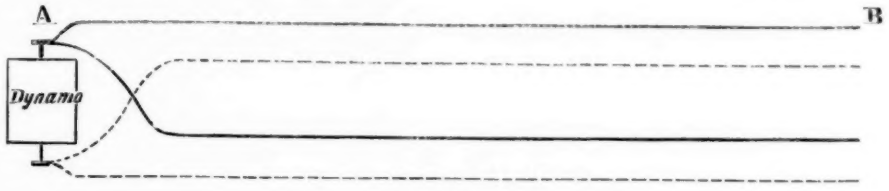


FIG. 10.

The circuit (fig. 9) was chosen with the view of simplifying the problem, but the circuit (fig. 10) will be preferred on the grounds of economy, because with the same quantity of material we get one quarter of the resistance and apparently less waste of energy caused by heating the conductors. But here we have

a varying resistance as the car proceeds on its journey from A to B, therefore a varying E.M.F., and with it a reduction in speed as the vehicle approaches the terminus furthest from the dynamo. In this case we have either to make the sacrifice of introducing artificial resistances when the motor gets near the generating station, or we have to allow the car to run slower and slower as it travels outwards. There, again, the fault is not very serious with one car on the line, but it offers real difficulties with a number of motors running simultaneously.

The effect of a variable conductor resistance can be easily calculated for any point, but it is interesting to plot curves or diagrams and thus show the variations graphically. Dr. Frölich, in the year 1883, gave a method represented in fig. 11.

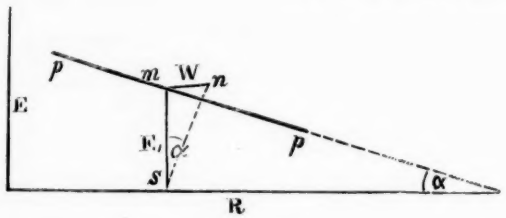


FIG. 11.

The resistances are drawn as abcissæ, and the E.M.Fs. as ordinates; the current is then at that point where no E.M.F. exists equal to the tangent of the angle, a. The fall of E.M.F. corresponding to the increasing resistance is represented by the line, p, p, and the electrical work, W, can be graphically represented from any point, m.

Thus $C = \tan. a$,
E_1 = the E.M.F. at any point, m,
$W = E_1 C = E_1 \tan. a$.

By drawing from m the line, E_1, at right angles to R, and from the intersecting point, s, a line, s, n, at right angles to p, p, we obtain m, n as the tangent, giving the work available at m.

The speed of a car on a perfectly level line will be proportional to the distance of the same from the imaginary point where lines p, p and R meet.

If there are gradients, then we have to plot the parallel components of the gravitation effects.

The requisite H.P. of the motor being known for all the gradients, the corresponding currents are easily ascertained. These currents give us the inclination of the E.M.F. line, p, p, in diagram, fig. 11; we are thus enabled to draw the E.M.F. line for any part of the road and construct upon it the corresponding work absorbed; in dividing the work by the tractive force we get the speed. In this way we may draw a chart which will show at a glance the energy expended as well as the speed at any desired point on the tramline.

In figs. 9 and 10 the generating stations were placed at one end of the line, but whenever convenient it is advantageous to place the dynamo half way, and thereby reduce the conductor resistance once more, *vide* fig. 12.

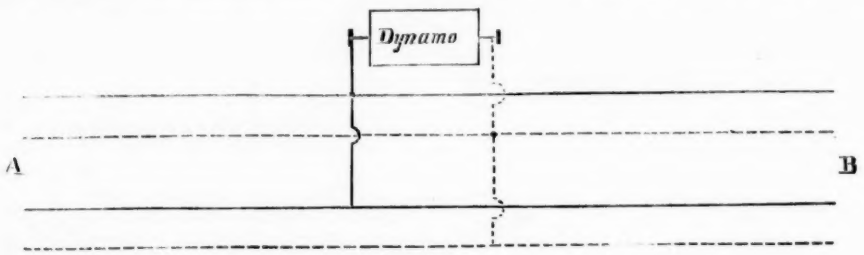


FIG. 12.

Telepraphic Revenue.—The receipts on the telegraphic service from April 1st, 1885, to February 13th, 1886, amounted to £1,535,000, against £1,550,000 received from April 1st, 1884, to February 14th, 1885.

LEGAL.

The "Otto" Engine in Germany.—The judgment in the case of Körting Brothers, of Hanover and London *versus* The Deutz Gas-Engine Works, was published in Leipzig on the 30th of January last, and is certain to have the greatest influence on the development of the German gas-engine industry.

The Deutz Gas-Engine Works were the owners of three patents (Dr. Otto's), which gave them the entire monopoly of the gas-engine trade in Germany. By their interpretation of the first claim in Patent No. 532, they asserted that they alone had the right to use an explosive charge consisting of a heterogeneous mixture of gas, atmospheric air, and indifferent gases or products of combustion, so that every gas motor which employed such a charge was considered by them to be an infringement of their patent rights, and builders of such engines were accordingly proceeded against. This claim was especially brought to bear against all engines using a heterogeneous mixture, in which the charge was ignited at that point where there was most gas, namely—at the port where the charge was admitted to the cylinder.

The second and third claims of Patent No. 532, extended the general principle described in the first claim to engines which worked without compression as well as those which compressed the charge previous to ignition. The fourth claim gave the Deutzer Gas-Engine Works the sole right to make engines worked on the so-called "viertact" or four-cycle principle, in which the same cylinder is employed as the pump and as the working cylinder.

If the first, second, and third claims gave them the sole right to employ a rational theoretical principle in the making of gas-engines, the fourth claim gave them the monopoly of the only rational mechanical method on which gas-engines can be built, and it is, therefore, not to be wondered at that these four claims were always considered by the Deutz Gas-Engine Works to be the most valuable part of their patent. In addition to these, there is, in Patent No. 532 (English 1876 Patent), a fifth claim, which is merely expressed by the words "the construction as described." This claim, which is found in many patents, was intended in this case, as it is in all others, to give the patentee a protective right against infringement of the general arrangement and construction of his invention as described in his specification, and signifies the erection or putting together of the separate parts so as to form a complete machine; therefore, any single detail, as such, is not protected by this claim. This has already been decided in former actions in which the Deutz Gas-Engine Works have been engaged.

It is to be noticed with regard to Patent No. 2,735 (English patent of 1877), that this only refers to the constructive arrangements, the special feature being claim two, concerning the slide, which is used in the present engines built at the Deutzer Works, and the novelty of which remains unquestioned by Messrs. Körting. In the first claim of this patent there is specified the arrangement of a port axial to the cylinder, through which the ignition flame is intended to pass, and by entering rapidly or, as it were, shooting into the midst of the explosive gases in the cylinder, to bring the whole charge at once to the point of ignition, and so produce an instantaneous explosion. This method of igniting the charge is, according to the specification, only intended to allow of the ignition of a homogeneous mixture in contradistinction to Patent No. 532 (1876), in which the mixture is to be ignited at that part which contains most gas. This claim, therefore, only refers to a detail in the construction to provide means whereby a homogeneous mixture may be ignited.

Further, the Deutz Gas-Engine Works possessed by their specification No. 14,254, a patent for the "special construction of a gas-engine with compression pump, and the method of work-

ing such an engine." So far as we know, the Deutzer firm have never made an engine according to this specification, probably for the reason that engines working with a compression pump cannot successfully compete with those which have only one cylinder.

In the recently concluded case Messrs. Körting had attacked the whole of Patent No. 532 (1876), and the first claim of Patent No. 2,735 (1877), the latter on account of the Deutz Gas-Engine Works having attempted to give a general interpretation to this claim also.

Besides Messrs. Körting, the firm of Buss, Sombart and Co., Magdeburgh, had also attacked Patent No. 532 and Patent 14,254.

By the decision now published of the "Reichsgericht" (the highest Court of Justice in Germany), the claims one, two, three and four of Patent No. 532, have been definitely invalidated and done away with. Of this patent there, therefore, only remains the fifth claim, which refers to the arrangement of the whole engine, as such, but which does not secure a Patent for any separate detail or method of construction. This claim has in any case no practical signification whatever, as, up to the present time, no engine has been constructed according to this specification.

The first claim of Patent No. 2,735 has also been allowed to remain, and also, of course, the second claim, the validity of which was not questioned. The Deutz firm, therefore, still retain their patent for the slide, and also for the long ignition port intended to produce an instantaneous combustion of the charge; and, further, the special constructive arrangement of the engine described in Patent No. 14,254, which, however, is of no great importance, as it would never occur to any one to make such an engine. On the other hand, the important principles of the Deutzer Patent, which for a long time have prevented free competition in the gas-engine trade in Germany, have now fallen to the ground.

The "Reichsgericht" has decided, that the four-cycle movement mentioned in the fourth claim of Patent No. 532, is not an invention of Dr. Otto; but, on the ground of being known to former inventors, shall be for the "common good of all." Therefore, every engineer is now free to build an engine on the four-cycle principle if he so wishes. Furthermore, the claims 1, 2 and 3 of this patent embodying the principle of the formation of the charge for engines with and without compression have been annulled, and in this case also it has been decided that this principle is no invention of Dr. Otto; but, in consequence of its having been known to older inventors, shall be public property, for the "common good of all." Every engineer is therefore at liberty to employ a heterogeneous mixture for the charge, and to leave a space at the end of the cylinder to contain that charge, which the compression necessitates in the "viertact" or four-cycle engine.

The invalidation of these claims has reduced the value of the Otto patents simply to the discovery of the before-mentioned details of construction, chief of which is the admission slide; this, and the long axial ignition port must not be infringed. The Körting gas-engine has neither an axial ignition port, since the port enters at the side of the cylinder, nor has it any slide whatever. The gas and air are drawn in through valves, and the arrangement for igniting is one which has been patented and used for some years. The firm of Körting Brothers, therefore, to whom the merit is due, of having conducted this case against the Deutzer Gas-Engine Works, with all imaginable pains and energy for more than three years, is now in a position to proceed with the manufacture and sale of their engines without interference.

Re The West African Telegraph Company, Limited.—Before Mr. Justice Pearson, Chancery Division of the High Court of Justice, Saturday, February 13th. A petition was made for the reduction of the capital of the company. The capital of the company, as fixed by the memorandum of association, was £1,000,000 in £10 shares. Of these only 2,000 shares have been issued, and nothing has been paid upon them. The articles of association authorised the company by special resolutions to reduce its capital, and a special resolution has been recently passed to reduce the capital to £400,000, in £10 shares. The petitioner asked for the confirmation of the reduction by the Court. By the leave of the Court the petition was brought on for hearing without any previous reference to Chambers for directions. There had been some preliminary advertisements of the petition. There was an affidavit stating that, with the exception of some small sums due for wages, the company had only one creditor for a sum of £3,800. This creditor had been served with notice of the petition and now appeared by counsel and consented to the proposed course. No prospectus had ever been issued of the company, the shares which had been issued having been subscribed for privately.

Mr. Everitt, Q.C., and Mr. W. Latham asked for the confirmation of the reduction, that the use of the words "and reduced" might be dispensed with, and that there should be no inquiry in Chambers as to creditors, and no further advertisement of the petition.

Mr. Stirling, for the creditor who had been served, assented.

Mr. Justice Pearson said that he felt some difficulty in dispensing with the use of the words "and reduced," because he thought that the public, who might be inclined to subscribe for shares, ought to know that there had been so large a reduction of the original capital. His Lordship also doubted whether he ought to exercise his discretion by dispensing with an inquiry in Chambers as to creditors. His Lordship said he would confirm the reduction, and would, upon an affidavit being filed that no prospectus had been issued of the company, dispense with the use of the words "and reduced" and with a reference to Chambers. The minute must be advertised in the *London Gazette*, and in *The Times* and the *Standard*.

Anders v. Schofield.—Schofield v. Anders.—These two actions, brought this week in the Lord Mayor's Court, were tried together, because the cause in each case arose out of the same matter. Mr. George Lee Anders said that he was an electrician. Last year he was desirous of going to America, and he asked Mr. Schofield, whom he had known for some time, to go with him. He (witness) offered to pay the expenses of the passage out, and then if anything "good" was to turn up Mr. Schofield should share in it. Plaintiff had a patent for a telephone, which was free from the Bell and Edison patents, which he thought he might be able to sell in the United States. Mr. Schofield lost his money playing "poker" on the passage out, and plaintiff had to advance him some, but he was not claiming on that account now. They did not do much business in America—only an hour or two, nearly the whole of the time being spent in pleasure. Shortly after they came back Mr. Schofield called at his office saying that he was in want of money, and asked plaintiff to lend him £200. Plaintiff lent him £50, and that amount he now claimed. The other amount of his claim, £45, was the balance of a bill of £65, which had been given by the defendant's firm, and which had been made over to the defendant to pay. The learned Judge ruled that the second half of the plaintiff's claim would have to be struck out. Mr. Schofield's version was that Mr. Anders offered him £500 and all his expenses if he would accompany him to the United States. Mr. Anders told him that the patent in America would be worth a hundred thousand dollars, and that he would not be able to conduct the arrangements in his own name, in consequence of his connexion with the London and Globe Telegraph Company, and that, therefore, he could afford to give him £500 for going with him. Witness never borrowed £50. He went to Mr. Anders and told him that as he had given up a position worth £500 a-year, he was in want of money, and would be glad to have the £500 he had promised. Mr. Anders then gave him £50 on account. The jury found for Mr. Anders in both cases.

Otto v. Steel.—This was a motion in the Court of Appeal to stay execution in a patent action pending an appeal. The defendant admitted infringement, and based his defence on the alleged invalidity of the claims in the patent. Dr. Otto had succeeded in a previous action of "Otto *v.* Lidford," in the Court of Appeal, in establishing the validity of his patent; but in the action against Steel a large amount of fresh evidence was adduced with a view of showing that the court in the former action was misled as to the scientific facts. The motion was made in the first instance before Mr. Justice Pearson. His Lordship refused to suspend the operation of the judgment, intimating that he had the less hesitation in doing so because the Court of Appeal, having control over the appeal business if it were considered a fit case, could advance the appeal. The defendant appealed, but the court refused to comply.

In Re The British Electric Light Company, Limited.—In the Chancery Division, on Saturday last, Mr. Justice Pearson made an order winding up this company. On Wednesday Mr. Rylands applied to the Court (*ex parte*) for the appointment of a provisional liquidator. The landlords, he said, had put in a distress upon the effects of the company, and threatened to sell to-morrow. It was thought that the best course would be to appoint a liquidator, who would pay the amount levied for, which was £200, if he thought fit. Mr. Justice Pearson: I shall not turn out the landlord, as I do not know that the liquidator will pay the money. You can have an injunction to restrain him from selling the goods until Saturday, and give short notice of motion for that day. Mr. Rylands: Is that necessary? Mr. Justice Pearson: Yes; as I do not know what the landlord may have to say.

Siemens Brothers & Co., Limited, v. The Assessment Committee of Woolwich Union.—This was an appeal in the Court of General Assessment against the valuation of large works covering an area of 6¼ acres and having a Thames frontage of nearly 500 feet, at Woolwich, which have been specially constructed and used for manufacturing the largest marine telegraph cables. The figures in the list were—gross value, £6,750; ratable, £4,500; and the appeal was to reduce to gross £4,200, and ratable £2,800. After evidence had been given by Mr. Ryde and Mr. Spencer Chadwick for the appellants, and by Mr. Morris, Mr. Cross, and Mr. Dinwhiddy for the respondents, the Court reduced the gross value to £6,000 and the ratable value to £4,000 without costs.

Re The International Electric Company, Limited.—In the Chancery Division of the High Court of Justice, on Saturday, an application was made to Mr. Justice Pearson to continue the voluntary winding-up of this company under a supervision order; and his Lordship acceded to the application.

NOTES.

The Electric Light in the Royal Navy.—A series of experiments have been carried out on board H.M.S. *Polyphemus*, at Portsmouth, in signalling with the electric light. Whilst the vessel was lying alongside the Slips Jetty, in the dockyard, communication was carried on with the flagship *Duke of Wellington*, lying in the harbour. This is the first time these experiments have been made at Portsmouth, and the result was looked upon as highly satisfactory. Commander R. W. White, from the Admiralty, has made a successful trial of the electric light apparatus on board the *Acorn*, sloop, Lieut. R. P. Bowden, at Devonport. He has since conducted trials on board the *Royalist*, corvette, at Devonport, and the *Woodcock*, armed tug, at Keyham. In each case satisfactory results were obtained.

The Electric Light at the Newcastle Election.—Considering the late hour at which the poll at the Newcastle election last week would probably be declared, and the inefficiency of gas illumination in St. Nicholas's Square for such an occasion, the authorities decided to bring the electric light to their aid. The arrangements were placed in the hands of Messrs. J. H. Holmes and Co., electrical engineers, of Newcastle. A portable engine was placed within a wooden structure erected in the Bigg Market, to work two powerful dynamos. Each dynamo worked a large arc lamp, the current being conveyed by wires taken from the dynamos to the top of the Town Hall. The lamps were supported by poles projected from the front cornices of the Town Hall. Each gave a light of 8,000 candle-power, and was so fixed that its light fell immediately on the board placed for receiving the numbers indicating the result of the poll. At a quarter-past six the lamps were lighted for a few minutes, and proved completely satisfactory. When they were lighted later on, they threw the gas lights into the shade, and brilliantly illumined the square of upturned faces beneath. The arrangement, considering the excitement which prevailed at the declaration of the last poll, says a local paper, was quite requisite, and reflected great credit on the forethought displayed by the authorities.

Gas Lighting for Ships.—The Plymouth correspondent of the *Times* states that it is very probable that experiments will shortly be made for the purpose of ascertaining whether gas can be used for illuminating small vessels of the Navy that are not at present fitted with the electric light. It is asserted by the promoters of the scheme that a sufficient amount can be stored on board the ships without materially interfering with their general stowage. Cleanliness, cheapness, convenience, and safety are claimed as the advantages of the system, but naval officers are rather sceptical about its practicability. We, for our part, are rather sceptical about its safety. Experiments are being made round the coast with buoys, and up to the present time the results have been successful.

The Inverness Telephone Exchange.—Twelve months have now passed since the Inverness Telephone Exchange was opened for business. Beginning with 46 subscribers on its list, the number at the close of the year has increased to 67—an increase of 21. The total number of messages which have been transmitted through the Exchange during the year reached the grand total of 64,525. As the average time taken to transmit each message was about three minutes, and as 300 words can easily be exchanged in that time, it is calculated that no fewer than 19,357,500 words have been exchanged between the subscribers during the year. In all the public offices the value and usefulness of the telephone as a means of communication is now fully understood, and duly appreciated. The manager, Mr. R. C. Bennett, deserves credit for the manner in which the exchange has been conducted.

Telephone Companies in America.—It is stated that quite a number of opposition telephone companies are springing up in various parts of America as a direct result of the Government's decision to go into the matter of the validity of the Bell patent.

Telegraph and Telephone Wires.—At the last quarterly meeting of the Andover Town Council the Town Clerk read a letter from the Telegraph Inspector at Salisbury, asking the Council's permission to erect two telephone posts in Weyhill Road, as there was a disturbance of the current along the telegraph wires by the present arrangement. If such consent were given the damage caused to the roads would be made good. Permission was granted conditionally upon the poles being of iron.

Trial Trip of a Cable Ship.—The trial trip of the twin-screw steamer *Mirror*, built by Messrs. R. Napier and Sons, at Lancefield, for the Eastern Telegraph Company, took place on Friday last in the Firth of Clyde. Built in accordance with designs by Mr. Joseph Birnie, the vessel is specially adapted for laying and repairing the company's submarine cables. She is built of steel, and is of the following dimensions :—Length, 250 feet ; breadth, 34 feet ; depth, 25·4 feet ; the gross tonnage being about 1,500 tons.

Foreign Electrical Agency.—Mr. Ernesto Danvers, A.S.T.E.E., Inspector-General of Colombian Telegraphs, writes from Bogota, that he has opened an agency there for the securing of patents, privileges and contracts for electrical materials and work ; and for supplying all information that may be required by firms intending to carry on business in the country. He mentions that there is a grand opening for the electric light.

The Society of Telegraph Engineers and Electricians.—The next meeting will be held at the Institution of Civil Engineers, 25, Great George Street, Westminster, S.W., on Thursday, February 25th, 1886, when the discussion on "The self-induction of an electric current in relation to the nature and form of its conductor," by Prof. D. E. Hughes, F.R.S., will be continued.

Tramcar Propulsion.—The articles "On Electric Locomotion" which appeared in the last and current numbers of the REVIEW, are well worthy of careful study by those who adhere to the conductor system of electrical propulsion. Mr. Reckenzaun has a happy way of making his papers readable and the principles contained therein easy to be grasped.

An Electric Furnace.—In our next issue we hope to give at length an illustrated description of the Cowles electric furnace, for the production of aluminium and its alloys.

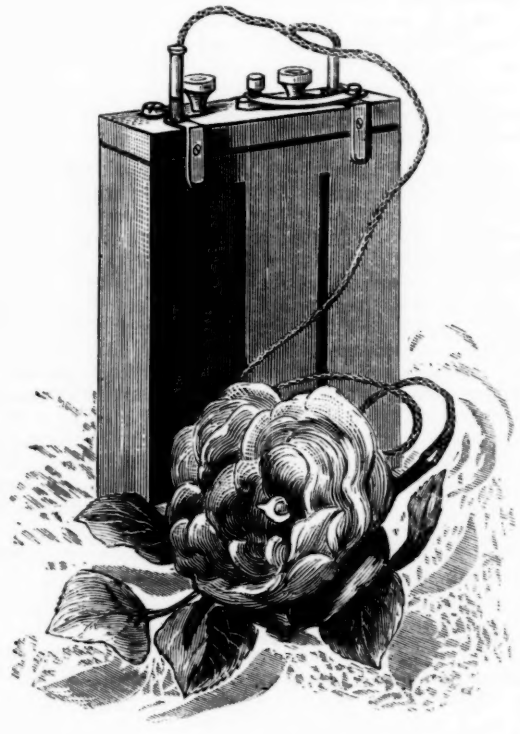
Secondary Generators or Transformers.—The Zipernowski-Déri apparatus to which Mr. Déri alludes in his lecture on "Alternating Currents," was minutely described and profusely illustrated in our issues of August 1st and 8th, 1885.

The Colchester Installation.—We shall be glad to know how many lights, if any, are now being operated in Colchester by the B. T. K. system.

Dynamo-Electric Machinery.—We would commend to the notice of our readers the comments to be found on our first pages on the book of Professor Silvanus Thompson.

Royal Encouragement of Science.—The King of the Belgians has just instituted an annual prize of 25,000 francs in order to encourage the publication of works of an intellectual order. This prize will be applied, in 1889, to a competition for the best work on the progress of electricity, as a motive power, as a means of illumination, and on the application to which it can be made in the future.

Pocket Primary Batteries.—In response to our enquiry for particulars of the above we have had two sizes of a new battery sent us for inspection. The apparatus consists of a vulcanite case divided into three cells, the elements in which are silver and zinc, excited by a special mercurial solution. The No. 1 size, which we illustrate, can be very readily carried in the pocket, being only 1 inch thick by 4 inches high and 3 inches wide; it is made perfectly watertight, weighs 1 lb. and holds about half-a-pint of solution. A switch attached to the battery will turn on or extinguish the light at pleasure. The parts are interchangeable, and the whole battery can be easily taken apart for renewals, &c. The No. 2 size is identical in



general form with No. 1, except that it is smaller, and weighs only half a pound. This size can quite readily be carried in the waistcoat or breast coat pocket, thus making it specially suitable for electric jewellery, &c. We tried the No. 1 size with one of Messrs. Woodhouse and Rawson's hair filament lamps, mounted inside a white rose; it ran continuously, without any appreciable falling off for a little over 2 hours. This is so far the best battery which we have yet seen for the purpose, and the ease with which it can be recharged certainly recommends it as all that can be desired. This battery has been introduced by the Woodhouse and Rawson Electric Supply Company, and may be inspected at the sample room of that company.

Society of Arts.—On Wednesday evening a paper on "Some Points in Electrical Distribution" was read at the Society of Arts by Prof. George Forbes, M.A., F.R.S.E. Prof. W. Grylls Adams, F.R.S., was in the chair, and the paper was received with attention and applause.

The Gramme Patents.—The Gramme patents having expired in France, dynamos have become cheaper in that country. The workshop dynamo (Gramme's *type d'atelier*), which used to cost 1,500 francs (£60), and lately cost 1,200 francs (£48), is now to be had for 600 francs (£24).—*Gas and Water.*

Telephonic Extension.—Telephonic communication has been established between Glasgow and Airdrie.

The Brighton Electric Railway.—At a recent meeting of the Watch Committee of the Brighton Town Council, a letter was read from Mr. Councillor Challis, inquiring why the electric railway car was not licensed and held amenable to the bye-laws in the same way as any other conveyance plying for hire. The town clerk reported to the committee that he had replied to Mr. Challis, informing him that Mr. Volk's electric car was neither a hackney carriage nor a stage carriage plying for hire in the streets of the borough, and did not, therefore, require a licence. The committee approved of the course pursued by the town clerk.

Working Guns by Electricity.—The question of training and working heavy guns by means of electrical motors has for some time occupied the attention of the War Office authorities, who have carried out a series of experiments. The system of employing small motors, actuated by a dynamo machine driven by a steam engine placed under cover in a sheltered position, will probably be adopted in preference to the present plan of transmitting the motive power by means of shafting. It is understood that the guns of the Spithead forts are to be immediately fitted with the new electrical training gear.

Electric Clock Control.—Clocks controlled by electricity are proposed to be erected in Birmingham, in twenty conspicuous places. The clocks, which will be public, will be illuminated by night. The town council estimate the cost of establishing these twenty clocks at £2,500, and the cost of maintenance to be about £200 per annum.

International Exhibition at Edinburgh.—One of the features of the exhibition will be the display of different systems of electric lighting. The incandescent lights in the main corridor are to be supplied by Messrs. King, Brown & Co. In the permanent building, as well as in several of the side courts, the Thomson-Houston system is to be introduced, while other sections of the exhibition are to be lighted by the Gülcher Electric Light Company, the Brush Light Company, and Messrs. Andrew & Co., Glasgow. The lighting of the grounds is still under consideration. Running parallel with the middle Meadow Walk an electric railway is to be fitted up by Mr. Holroyd Smith, of Halifax.

Lecture.—On Saturday week Mr. J. G. Fairweather, B.Sc., C.E., Lecturer on Engineering at Heriot-Watt College, Edinburgh, delivered a lecture on Domestic Electric Lighting at St. James's Hall, Edinburgh. The lecture was illustrated with a number of electric lamps and apparatus, provided and fitted up by the Scottish Electric Light Company.

The Dire Effects of the Electric Light.—"Sunshine," it is known, has a powerful and peculiar effect upon some mortals, causing a staggering gait and a rambling mode of thought and utterance; we are now convinced that the electric light, when of sufficient power, is capable of producing similar phenomena. A young man recently "went out for to see" Sir David Salomon's 60 volt, 40 ampère, 2,400 watt lamp at Broomhill, and he tells the awful story of what resulted in the *Maidstone and Kentish Journal* in the following words:—"A most conspicuous object for very many miles around Southborough is now the new electric light, equal to 15,000 candle-power, which Sir David Salomons has lately erected on the summit of his lofty astronominal tower observatory. Its effect over the snow-covered country last week was especially brilliant and vivid, assisted out of the carriage little the worse, except for the shock. The carriage had to be removed for repairs, the lady going home by other means. The milk cart, which was from Penshurst, was also rather damaged, but the driver fortunately escaped unhurt."

Ocean Currents.—The question of ocean research is one of general interest, and all efforts in this direction, whether undertaken by private individuals or by governments, should meet with the warmest sympathy. The geographer, the navigator, the scientist, and last, but not least, the telegraph engineer, are alike interested in ocean exploration. We give our readers the substance, naturally much condensed, of a long article in the French illustrated paper *L'Illustration* of February 13th, on the subject of ocean currents, and more especially with regard to some experiments lately made in the neighbourhood of the Azores on the direction of the Gulf Stream. It appears that in July of last year the Hereditary Prince of Monaco, accompanied by Mons. G. Pouchet, professor at the Paris Museum, started in the Prince's sailing yacht *L'Hirondelle*, with the intention of crossing the Gulf Stream somewhere in the vicinity of the Azores, and dropping at intervals floating vessels containing the following notice in French, with full instructions in Russian, Norwegian, Danish, English, German, Dutch, Spanish, and Portuguese: "With the object of studying the ocean currents, assisted by the Municipal Council of Paris, this document has been thrown into the sea under the direction and in the presence of His Highness the Hereditary Prince of Monaco, on board his yacht the *L'Hirondelle*. Whoever finds this paper is requested to hand it to the authorities of his country to be transmitted to the French Government, at the same time stating with all possible details the place, date, and circumstances connected with the finding of this document.

(Signed) ALBERT, Hereditary Prince of Monaco.

(Signed) G. POUCHET, Prof. at the Paris Museum."

Each copy of the above notice, torn from a book in which a counterpart is kept, carries a serial number, and is enclosed in a glass tube hermetically sealed. The notice is rolled up with the printed matter outside, so that its polyglot character may be seen without breaking the glass. The floating vessels containing the tubes were of three patterns. 1. Ten copper spheres, 0·30 metres in diameter, composed of two semi-spheres, screwed together over an India rubber joint. 2. Twenty 16-litre barrels, with exceptionally strong staves, bound with iron hoops, and tarred inside. 3. One hundred and fifty ordinary bottles, the corks protected by an India rubber cap. The barrels were filled with chaff, and were ballasted with cast iron weights of about 20 kilos. each, attached by wire to wooden hoops on the barrels. Some of the bottles were thrown overboard on July 27th, commencing at a position about 110 miles N. 27° W. of Corvo (the most westerly island of the Azores), and were deposited at about a mile apart. The barrels and spheres were then let go at intervals of two miles, and the remainder of the bottles were then got rid of. The course made during the immersion of the vessels was N. 14° W. over a distance of 170 miles. Out of the 180 floating vessels thrown overboard, six have been recovered up to date. Numbers 9, 133 and 136 were picked up at San Miguel. Number 22 at Santa Maria; number 1 on the north side of Pico; and number 30 at Terceiva. The description given is not very clear as to how the vessels were immersed with regard to their numbers, nor are the dates of recovery given, but it is deduced from the vessels let go nearest to the Azores having taken the longest time in reaching those islands that the Gulf Stream forms a considerable eddy round the islands. From these experiments it is also claimed that:—1. Up to a distance of 300 miles to the N.N.W. of the Azores, the Gulf Stream, instead of having a N.E. direction, as generally supposed, has actually a direction of S. 35° to 40° E. 2. No part of the Gulf Stream proper reaches the coasts of France. That is to say, no portion of it from the positions where the vessels were let go. 3. If any part of the Gulf Stream actually reaches the French coast it must be looked for to the north of the forty-second parallel, but it is not probable that the Gulf Stream has any effect north of lat. 40°. 4. The mild climate on parts of the French coast is due to surface currents influenced by prevailing winds. Considering that only six vessels out of the 180 immersed have been recovered, and that the experiments have been carried on comparatively close to the Azores, and therefore, subject to local influences, it is rather premature to express any opinion as to the results so far obtained, but, whether these experiments prove valuable or useless, the Prince has certainly taken a step in the right direction, and he deserves every commendation for his endeavours.

Post Office Telegraphs.—A return has been issued, in accordance with an order voted in the House of Commons, showing the gross amount received and the gross amount expended in respect of the telegraph service from the date of the transfer of the telegraphs to the State in 1870 to the 31st day of March, 1885. From this it appears that the total receipts in 1885 amounted £1,784,414, which sum was less by £36,350 than the expenditure for the same year, £1,820,764. In the year 1884 the expenditure was £1,789,223, and the deficit then was £19,697. These are the only two years since 1870 in which the expenditure has been higher than the receipts.

Tests of Dynamos.—Mr. George Hookham, of the firm of Chamberlain and Hookham, Birmingham writes (too late for insertion in our correspondence columns):—"It seems a pity that a suggestion started in your REVIEW by Mr. Crompton, and seconded by Mr. Elwell of Wolverhampton, should be allowed to fall through. I refer to the proposal for a dynamo competition. Would not you, Sir, be willing to do something to forward such a movement? A good preliminary would be to collect and collate opinions as to the *points* of dynamos, their relative value, and the method of ascertaining them. These might be contributed by makers and others, and if you would undertake their analysis, much would be done to clear the ground for a competition. My firm, for example, would be glad to furnish such a list of suggested *points* if others would do the same."

We shall be pleased to do whatever is in our power to forward this matter, and shall be glad to hear from all manufacturers on the subject.

Country Agency.—Messrs. Walker & Olliver, of Cardiff, Leeds, and Newcastle, have been appointed agents for those districts by Messrs. Heap and Stuart for the sale of their incandescent lamps and the Buffalo carbons, and other specialties.

NEW COMPANIES REGISTERED.

Gas and Light Company of Portugal, Limited.—Capital £100,000 in £5 shares. Objects: To carry on in Portugal, the Portuguese possessions, or elsewhere, the business of gas manufacturers and electrical engineers and every other business connected with the manufacture of gas and electricity. Signatories (with one share each): Hy. Cade, 19, Runton Street, Holloway; G. Pye, 4, West View, Hendon; A. Stein, 17, Great Winchester Street; F. J. Jones, 257, Uxbridge Road; F. Howell, Dunstable; F. O. Moore, 10. Adelphi Terrace; H. Ogle Moore, Addlestone, Surrey. The first directors are the Hon. Wm. Arnnand, Richard Wood, J. P. and W. Fletcher Gordon; qualification 20 shares; remuneration £500 per annum, with £200 per annum additional for each concession taken over by the company after the first. Registered 16th inst., by George Daniels, 7, Woodford Road, Watford, Herts.

Simplex Electrical Syndicate, Limited.—Capital £6,000 in £50 shares. Objects: To purchase the following letters patent, viz.: No. 3,905, dated 25th February, 1884; No. 15,030, dated 14th November, 1885, and No. 7,390, dated 17th June, 1885, granted for improvements in electric arc lamps; and No. 12,840, dated 26th October, 1885, for improvements in secondary batteries. Signatories (with five shares each): C. L. Wingfield Fitzgerald, 4, Hercules Passage, Threadneedle Street; A. H. Baker, 31, Throgmorton Street; W. W. Bateman, Cornhill Chambers; R. E. Bateman, Reigate; F. C. Stoop, 46, Penywern Road, Earl's Court; H. Grewing, 26, Queen Anne's Gate; H. B.

Muir, 192, Cromwell Road, S.W. Registered 15th inst., without articles of association, by Hollams, Son and Coward, Mincing Lane.

Hirsh, Greystock & Co., Limited.—Capital £50,000 in £10 shares. Objects: To purchase the business of Walter Moser, portable electric light manufacturer, trading as Hirsh, Greystock & Co., at 11, Queen Victoria Street. Signatories (with one share each): H. P. Bernard, 107, Cannon Street; F. B. Reynolds, Addiscombe; A. C. Bell, 22, St. John's Grove, Croydon; W. Moser, 11, Queen Victoria Street; C. J. Reeve, 45, Fonthill Road, Tollington Park; G. J. Carringham (electrician), 21, Gilmore Road, Lewisham; R. T. Linford, Rosedale Place, Ealing. The directors (other than the first) will be required to hold £500 of the share capital. The remuneration of the board will be £850 per annum. Registered 15th inst., by A. C. Bell, 11, Queen Victoria Street.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES

Eastern and South African Telegraph Company, Limited.—The annual return of this company made up to the 21st July, 1885, was filed on the 12th inst. The nominal capital is £400,000, divided into 20,000 "A" and 20,000 "B" shares of £10 each, the whole of which are taken up and are fully paid.

Spanish National Submarine Telegraph Company, Limited.—The annual return of this company made up to the 12th ult., was filed 12th inst. The nominal capital is £500,000, divided into 49,900 shares of £10 each, and 1,000 shares of £1 each; 23,719 of the former have been allotted, and £10 per share has been called thereon. £30 has been received in payment of calls, and £237,160 is considered as paid up. The total amount of shares for which share warrants are outstanding is 2,304.

West London Electric Lighting Company, Limited.—At an extraordinary meeting of this company held at 38, Old Broad Street, on the 19th ult., it was resolved that "A Bill to make further provisions respecting the undertaking of the West London Electric Lighting Company, Limited, and for other purposes," to be introduced into Parliament in the present Session, be approved. The resolution was confirmed on the 9th inst., and registered 12th inst.

Railway Electrical Contractors, Limited.—At a meeting of this company held at 144, Leadenhall Street, on the 3rd December, it was resolved that Article 7 of the articles of association be amended by adding thereto the following words:—"Subject to any such rights or privileges, and to any special directions which may be given by the company in extraordinary general meeting, the shares of the company shall be under the control of the directors, who may sell or otherwise dispose of the same to such persons, on such terms and conditions, whether at a premium or discount or otherwise, and at such times as the directors may see fit." The resolution was confirmed on the 31st December, and registered 12th inst.

Standard Time and Telephone Syndicate, Limited.—The registered office of this company is at 19 and 21, Queen Victoria Street.

CITY NOTES, REPORTS, MEETINGS, &c.

Submarine Telegraph Company, Limited.

THE ordinary general half yearly meeting of this company was held at the offices, 2, Throgmorton Avenue, E.C., on Tuesday, Sir Julian Goldsmid, chairman of the company, presiding.

The report, which was taken as read, stated that the receipts for the six months ending 31st December, 1885, amounted to £64,782 0s. 4½d., being £456 19s. 11d. more than in the corresponding six months of the year 1884, while the expenses have been less by the sum of £75 2s. 4d. The net result of the business for the six months enables the directors to add £8,083 0s. 10d., the usual proportion of the gross receipts, to the reserve fund, and to recommend a dividend at the rate of 14½ per cent. per annum, leaving a balance of £414 3s. to be carried to the next account. For the corresponding period of 1884 the dividend was 14 per cent., and the balance carried over £377 18s. The receipts from the ordinary traffic for the six months were somewhat less than in 1884, although there were 62,351 more messages transmitted, but the average length of those messages was only 11·44 words against 11·91 in 1884. There has been also a falling off in the receipts in respect to the messages transmitted by the Eastern Company over the wire leased to that company, partly by reason of the reduction in the inland rate of telegrams on the 1st October last. But, on the other hand, there has been an increase in the special receipts from the fresh arrangement made with the Indo-European Company, referred to in the last report, and from an agreement recently entered into with the Commercial Cable Company for the use of a special wire to Havre for the transmission of their French-American messages. The company's cables, as well as those under the care of the company, have, with two exceptions, been worked during the half year without any interruption. The exceptions are the Dieppe Cable and the cable between Salcombe and Brest; the former was broken on the 14th and repaired on the 22nd of December, and the latter was broken on the 25th October and repaired on the 14th December, 1885. In the last report it was stated that the cables during the first six months of the year were also remarkably free from interruption; consequently the repairing ship was in port for many months. The drawback paid by the insurance company at the expiration of the yearly policy in August was £486, or £160 10s. more than the charge for insurance for the six months ending December, 1885. This is the reason for the absence of the usual charge in the accounts under the head of "Insurance of Steamer." The sum of £160 10s. will, morever, be credited to revenue in the next accounts. An International Telegraph Conference was held at Berlin in August, when the company was most efficiently represented by Mr. George de Bunsen. The result of the conference was that some of the telegraph charges were reduced, but the slight modification in the rates between this country and the Continent of Europe will not, it is expected, prejudicially affect the company's revenue. The new rates do not, however, come into operation until 1st July, 1886. All the company's cables, as well as those worked by the company, are at the present time in good working order.

Mr. S. M. Clare, secretary, having read the notice convening the meeting,

The Chairman, in moving the adoption of the report and accounts, said he thought, on the whole, the report was satisfactory. If they had read it they would have seen, in the first place, that in consequence of the improved condition, especially of the Dieppe cables belonging to the government, which, they would remember, were either partially or completely renewed not long ago, they had had very few breakages in the cables, and the result had been that their ship had been at home for the greater part of the half-year; a curious part of this circumstance was, that the drawback allowed by the insurance company was in excess of the premium they paid; and, therefore, they had no insurance to pay, and the balance went to the next half-year's accounts. The principal repairs had been in the Dieppe cable, in which something over 3½ miles of new cable had been put, and in the Salcombe, which took 1¼ mile of new cable. These two were done at the same time, so that practically one outing on the part of the ship accomplished all that was required. This was a matter of congratulation. But when he came to other points he was not equally satisfied. He had told them for some time past what was the condition of affairs with regard to the traffic. He had told them that they had a steady increase of traffic, and a steady decline in the length of messages. He held tables in his hand which showed that that increase and decrease continued, for whereas in the half-year which ended on December 31st, 1884, they had 1,428,520 messages, there was an increase in the half-year ending December 31st, 1885, to 1,490,891. The words had increased from 17,007,766 words to 17,062,135; but the average length of the messages, which was 11·91 words last year, had now decreased to 11·44, showing that the system of compressing messages was still going on. He had often said here, and must now repeat, that he could not tell where the limit of fall in this respect was. Of course, there was a limit somewhere, but they had not yet been able to ascertain where, and he noticed that in the returns for the month of January there was a still further decline in the average. This was an unsatisfactory side of affairs, and he had thought it his duty to put all the information he reasonably could before the shareholders upon this subject. In the report they referred to the Telegraph Conference, and he should like to say, on behalf of the board, that Mr. George de Bunsen represented the company at Berlin with great success. He belonged to a family of diplomats, and they were fortunate in having so able a man to represent the company. The alterations made in the international charges were comparatively small, and would not do this company any injury; those alterations would come into operation on July 1st. They had lost one newspaper, *Le Telegraphe*, a French paper; and the *Daily News* had leased a wire for three hours a night, showing that it is an enormous advantage to the Press to be able to use a wire for their own purposes without the knowledge of anyone else. The company assisted very materially the spread

of information over the whole world in this way. Altogether, he thought their affairs were in a satisfactory state, and the dividend the directors were able to recommend was a good one, under all the conditions.

The Right Hon. Robert Bourke, M.P., seconded the adoption of the report.

A Shareholder remarked that the merchants of Liverpool were complaining of their lack of facilities for telegraphing to the Continent, and he desired to know if the matter affected this company.

The Chairman stated that two or three years ago, as now, the Liverpool merchants wanted a special cable to carry their messages; but the Post Office and this company went into the matter, and found that the traffic would not be nearly sufficient to justify a separate cable for the purpose. The complaints of delay affected the landlines, and not the submarine system; but some of those complaints, upon being investigated, proved not to be well-founded.

The motion was then put and carried unanimously.

The Chairman moved: "That in accordance with the recommendation of the directors, a dividend for the half year to 31st December, 1885, at the rate of 14½ per cent. per annum, less income tax, be declared, to become payable on March 1st."

The Hon. Ashley Ponsonby seconded, and the motion was carried, a vote of thanks to the Chairman thereupon terminating the meeting.

The Maxim-Weston Electric Company, Limited.

THE directors' report is as follows:—The directors beg to remind shareholders that no allowance was made during the past two years for contingencies such as are referred to in section R of clause 75 of the articles, and they have now deemed it prudent to pass the sum of £3,606 5s. to the credit of a general reserve account.

After making the above reserve the total balance at credit of profit and loss account, including amount brought forward from previous year, is £5,284 19s. 8½d.

The directors recommend the payment of 7½ per cent. dividend, which will leave a balance of £597 9s. 8½d. to be carried forward to next year.

The directors having obtained the sanction of the Court to the reduction of capital, patents account has been reduced to £35,000, which includes outlays during the past year in connection with new patents.

The plant and machinery at factory have been valued in minutest details, as in the case of last year, in the presence of the Chairman, under the supervision of the works manager.

The directors estimate that £600 will cover the total bad debts incurred by the present management, including outstanding debtors.

Owing to the growth and present requirements of the business, the directors have been compelled to look out for larger manufacturing premises, and hope to secure in a few days a suitable factory upon lease, at a moderate rental.

The commodious premises referred to will give much needed facilities for manufacturing and testing purposes, and will effect a large saving in labour—the factory, which consists of only two floors (instead of six, as formerly), containing more than four times the cubic area. The different departments will thus be constantly under the supervision of the manager.

The electrical staff of the company, so as to keep pace with their more enterprising competitors, are constantly engaged in experiments which so far have resulted in great improvements in our systems.

The directors are happy to be able to report a rapid development of the business, and having now established agencies in nearly every quarter of the globe, which their patent rights include, are in hopes of showing a larger balance of profit at the end of the current year.

The Chairman trusts to be of some service in obtaining the removal of restrictive legislative enactments, and is in hopes that the Government will approve of certain amendments to the Acts of 1882, which ought to give a further stimulus to the business.

Balance Sheet, 31st December, 1885.—*Dr.*—To capital issued, £62,500; to calls unpaid, £2 10s.; to creditors, £1,150 9s. 9½d.; to bills payable, £254 5s. 4d.; to reserve account, £3,606 5s.; to profit and loss, £5,284 19s. 8½d.; total, £72,793 9s. 10d. *Cr.*—By patents, £35,000; by machinery and stock at factory, £12,285 14s.; by furniture and fittings at office and factory, £170; by shares in Electric Sun Lamp and Power Company, Limited (£4,625), estimated at 2s. 6d. in £, £578 2s 6d.; by debtors, £12,794 15s. 6d.; by cash at banker's and on deposit, £11,964 17s. 10d.; total, £72,793 9s. 10d.

German Union Telegraph Company, Limited.—The net profit for the year ended December 31st, 1885, after paying 59,408 marks to the reserve funds, and a similar amount to the renewal fund, and paying the dividend on the original preference shares, is sufficient to allow of a dividend of 7 per cent., of which 4 per cent. was paid last month.

Western and Brazilian Telegraph Company, Limited.—Holders of share warrants to bearer are notified that in order to obtain the dividend of 2¾ per cent., declared at the annual general meeting on the 21st ult., they must deposit the warrants at the offices of the company.

Great Northern Telegraph Company, Limited.—The numbers are published of 100 debentures of 1883 (series B), drawn at Copenhagen on the 23rd ult., for payment on March 1st, at the offices of Messrs. C. I. Hambro & Son, 70, Old Broad Street, E.C.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending February 12th were £2,646, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 15th February are £2,551, as compared with £2,339 in the corresponding period of 1885.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

AN ordinary general meeting of this society was held on Thursday, February 11th, Sir CHARLES BRIGHT, Past President, in the chair. The minutes of the last ordinary general meeting having been read and confirmed, and the list of new and proposed new members announced, a discussion on Professor Hughes's paper (Inaugural address) on "The Self-Induction of an Electric Current in Relation to the Nature and Form of its Conductor" was commenced.

LORD RAYLEIGH, in opening the discussion, pointed out that Professor Hughes did not use the term "self-induction" in the sense which Clerk Maxwell and others employed it. The term could be expressed as a definite quantity which was independent of the metal experimented on, except in the case of magnetic metals. The element of resistance enters into the question, so that if we call L the self-induction, R the resistance, and τ_1 time, then we have

$$\frac{L}{R} = \tau.$$

The quantity τ had been called by him the "time constant." The method of measuring self-induction suggested by Clerk Maxwell was that of obtaining stable balance on a Wheatstone bridge, one arm of which contained the resistance whose self-induction was required, and then making and breaking the battery circuit and observing the throw of the galvanometer needle; the value of the galvanometer constant was observed by obtaining a small permanent deflection. The magnitude of the electromotive impulse when contact was made depended upon the coefficient of induction, and also upon the current. He doubted whether in Professor Hughes's method the two quantities were sufficiently separated. No ambiguity would arise provided the wires dealt with had all the same resistance. Maxwell gives two methods of measuring self-induction, but those methods are probably not applicable to Professor Hughes's apparatus. In Maxwell's book the case of two long parallel conductors was dealt with, an equation of the form

$$\frac{L}{l} = 2\mu_0 \log. \frac{b^2}{a_1 a_1'} + \frac{1}{2}\mu + \frac{1}{2}\mu'$$

being obtained. In this equation a_1 and a_1' were the respective radii of the wires, μ_0 the magnetic permeability of the air, b the distance between the centres of the wires, and μ and μ_1 the magnetic permeability of the wires themselves. The latter quantities are very high numbers in the case of magnetic metals. He would point out that the quantity, log. $\frac{b^2}{a_1 a_1'}$, was not correct unless μ and μ_1 were equal. Professor Hughes by his experiments brings out the fact that, in the case of iron, the division of the flat ribbon into strips did not make any difference in the effect, but in the case of copper it does; this is perfectly in accordance with the equation of Clerk Maxwell. The formula before mentioned became considerably modified if the wires were close to each other as then the mutual reaction came into play; this point Maxwell had not dealt with. In the case of two concentric tubes the problem became more easy, and if the space between the tubes was very small, the cylinders of the same material, and also if the cylinders were very thin as compared with their radii, then calling r the common radius and c the thickness, the total section of each ring would be πc^2, and the equation of self-induction would be

$$\frac{L}{l} = \frac{2\mu c^2}{3r^2}\left(1 + \tfrac{1}{15}\frac{c^4}{r^4} + \text{etc.}\right)$$

This equation shows that if c is preserved constant, then by increasing the radius *the self-induction may be reduced to any extent we please.* Maxwell in dealing with the problem recognised only two qualities, viz., magnetic permeability and resistance. The question raised by Professor Hughes's experiments is whether there is any effect other than that which is not caused by resistance alone. The carbon and metal results are curious, and the question arises whether the results obtained were in any way due to the form of the apparatus itself. As regards the effects

observed with stranded iron wire he rather thought that they were due to the strands being separated from each other by a stratum of air, the quantity μ_0, in fact, being very small. The results in the case of copper strand were difficult to understand; they might possibly be due to some facts not yet brought out, though he thought there was probably only a misunderstanding of *terms* and not a new fact discovered. Lightning conductors, it was pointed out, might either act to enable electricity to be discharged with facility or to prevent its accumulation. Speaking of the action of the telephone Lord Rayleigh stated that it had been argued that a certain amount of magnetism was necessary for proper action; this he did not find confirmed by his own experiments. Referring again to the constants μ he pointed out that they only remained so as long as the point of saturation was not attained; after that point they became variables.

Mr. FRANK POPE said it was 30 years since he entered the telegraph service; at that early period many phenomena were observed which could not be accounted for. Some of these had subsequently been explained, but others now became evident as a consequence of Prof. Hughes's researches. The burning of coils by lightning, even when the line was earthed close to the coils, was now comprehensible. In the type printer of House, it was noticed that much better work was obtained on a stranded than on a solid wire, though, as far as could be judged at that period, their resistances must have been about equal; at the time the fact was put down to the supposition that the current flowed only over the *surface* of the wire. The discovery that the coils of an electro-magnet, when joined up in multiple arc, gave a much higher speed in Wheatstone automatic instruments than when the same resistance of solid wire was used, was also explicable from Hughes's experiments. In 1876, an automatic system with a Bain recorder was worked over a 100-mile line at a rate of 1,000 words per minute; the wire used was a compound copper steel one, The same speed could not be obtained over an iron wire; but it was not proved that a plain copper wire would not give equally good results, as the experiment could not be tried.

Prof. FORBES pointed out that the case of an earth wire being unable to protect the coils of a telegraph instrument had an analogy in the case of a gun bursting when fired if the muzzle were loosely plugged with snow. The influence of an iron sheathing round a conductor might lead to important modification in the construction of submarine telegraph cables, thus the use of a sheathing of gun metal might enable the working speed to be increased. The self-induction of an Atlantic cable, he pointed out, was enormous. The remark of Lord Rayleigh that all the results obtained by Prof. Hughes had been foreshadowed by Clerk Maxwell, was, he thought, rather hard, as a careful going into the matter would, he was of opinion, reveal that there was more in the experiments than at first sight might be imagined. He considered that the question of the coefficient of self-induction was not the only point to be dealt with, and that new facts had really been discovered. Lord Rayleigh had said that on stable equilibrium being produced, then when induction causes this to be out, a new balance can be obtained. Now, as a matter of fact, this new balance would be different for making and for breaking contact; but Hughes gets a balance which is the same for both. Maxwell's results are not in harmony with those of Hughes. In the case of wires of different thicknesses, the equation for the induction is

$$L = L_1 \frac{d c}{d t};$$

but for a strip we have

$$L = R C + a \frac{d c}{d t} + b \frac{d^2 c}{d t^2}.$$

When the two last terms are equal to 0, then we have the condition for stable equilibrium. The self-induction in the middle of a strip is greater than it is at the edges, and this is still more marked in the case of a cylinder; so that a current circulates in the wire, the direction of which is reversed when the circuit is broken. This consideration completely explains all the phenomena obtained by Hughes. Seventeen facts mentioned in the paper are thus accounted for.

Dr. HOPKINSON said that with regard to methods of measuring self-induction, he had suggested one which was a modification of that of Clerk Maxwell, two galvanometers being used, one of which was in the battery circuit. Prof. Forbes had touched upon the distribution of currents in conductors when self-induction takes place; when a current is put on this distribution is not uniform, but changes from the centre to the circumference of the wire or strip. The question of round *versus* flat lightning conductors had, he thought, been completely settled by the experiments of Hughes.

The discussion was then adjourned.

NEW PATENTS—1886.

1916. "Electric wig or other head dress." G. EPSTEIN. Dated February 10.

1946. "Diaphragms for telephones, phonographs and the like." G. C. TAYLOR. Dated February 10.

1947. "Phonographic or sound or speech-producing implement for use in lighthouses, &c." G. C. TAYLOR. Dated February 10.

1999. "Electric lamps for use for lighting in mines, railway carriages, &c." J. W. SWAN. Dated February 11.

2002. "Applying electricity to the scalp or head for curative or other purposes." G. LICHTENFELD. Dated February 11. (*Complete.*)

2012. "Regulating apparatus for arc electric lamps." J. D. F. ANDREWS. Dated February 11.

2013. "Electric lamps." J. D. F. ANDREWS. Dated February 11.

2067. "Automatic electrical circuit switches." C. A. GISBORNE. (Communicated by F. N. Gisborne and D. H. Keeley.) Dated February 12. (*Complete.*)

2080. "Electric switches." A. BERNSTEIN. Dated February 12. (*Complete.*)

2081. "Telephonic apparatus." L. DE COMBETTES. Dated February 12. (*Complete.*)

2169. "Army electric signalling lamp." A. LOVELL. Dated February 15.

2193. "Fittings of mechanical telephones." W. J. BURNSIDE. Dated February 15.

2242. "Electro stylo aureo graphic pen and pencil." C. A. TESKE. Dated February 16.

2268. "Transmitting, reproducing and recording speech and other sounds." C. A. BELL. Dated February 16.

2282. "Separating magnetic from non-magnetic substances." H. H. LAKE. (Communicated by H. Kessler.) Dated February 16.

CORRESPONDENCE.

Telegraphing to and from Moving Trains.

Apropos of an article on this subject in your issue of December 19th, 1885, I beg the favour of your inserting in an early number the following words which were spoken in a lecture as far back as 1838:—

"And now I have a few words to say upon what must be considered another application of electricity, namely, the purposes it will answer upon a railway, for giving notices of trains, of accident, and stoppages. The numerous accidents which have occurred on railways seem to call for some remedy of the kind; and when future improvements shall have augmented the speed of railway travelling to a velocity which cannot at present be deemed safe, then every aid which science can afford must be called in to promote this object. Now, there is a contrivance, secured by patent, by which at every station along the railway line, it may be seen by mere inspection of a dial, what is the exact situation of the engines running, either towards or from that station, and at what speed they are travelling.

"At every railway station there will be a dial, like the face of a clock, on which, by means of a hand, or pointer, it may be seen where any particular train may be at any particular instant. Every time the engine passes a milestone, the pointer on the dial moves forward to the next figure, a sound, or alarum, accompanying each successive movement.

"Not only this, but if two engines are approaching each other, by any casualty, on the same rails, then, at a distance of a mile or two, a timely notice can be given in each engine, by a sound, or alarum, from which the engineer would be apprised to slacken the speed; or, if the engineer be asleep, or intoxicated, the same action might turn off the steam, independent of his attention, and thus prevent an accident."

The above words will be found printed at pages 407–8 of my "History of Electric Telegraphy." At the time they were uttered (in 1838) probably not one man in a million in England believed in the possibility of electric telegraphs of any kind. All honour, then, to the memory of Edward Davy, their gifted author.

The MSS. from which these passages are taken, and which I have had the rare fortune to bring to light after an interval of nearly fifty years of oblivion, are now in the library of the Society of Telegraph-Engineers and Electricians, and will well repay perusal. In the words of a distinguished electrician:

"They show that the humble occupant of 390, Strand, London, was not only an ingenious inventor, but a clear-headed and far-seeing man. Of his peculiar, and even wonderful, grasp of the properties of electricity there can be no question. One cannot help feeling, as one reads the highly suggestive notes and confident anticipations with which his memoranda and letters are crowded, that had he remained in England to steer the destinies of the electric telegraph it would have made more progress than in other hands it actually did make. What he accomplished was clearly the outcome of his own original mind, and what he predicted as possible, but allowed to be fulfilled by somebody else, also belongs to him."

I may mention that Edward Davy died on the 26th January, 1885, but not before he had received a due acknowledgment of his undoubted claims.

J. J. Fahie.

Teheran, Persia, *January 16th*, 1886.

The Use of the Tangent Galvanometer.

It may interest your readers to know that the tangent galvanometer can be rendered twice as sensitive, and have a greater reading range by turning the coil so that the needle stands normally at 100 divisions on the tangent scale, or 60° on the degrees scale.

A current which would under ordinary circumstances deflect the needle from zero to 100 divisions on the tangent scale, would deflect the needle from the new zero (100) to 100 divisions on the other side of the scale.

The intermediate tangent divisions would accurately represent intermediate strengths of current; the tangent could, therefore, in its new position be shunted so as to give half its ordinary resistance, and still admit of 100 divisions being obtained with the new position, as against 100 divisions in the old position with a higher resistance in the galvanometer circuit.

A further advantage is gained, in so far as in the ordinary method readings of 80 to 100 divisions must be taken on a part of the scale which is difficult to read from; but a similar reading on the new method would be taken on the larger tangent divisions with great ease.

When an instrument with thick coils is used, and where the external circuit is so low that a battery liable to polarisation is falling in force during the time the needle is swinging round to its point of maximum deflection, the final deflection is less than that which would be indicated if polarisation had not interfered. To enable an instantaneous reading to be taken, a bar magnet may be placed so as to deflect the needle and to indicate approximately the number of divisions which the current will give; and when the current is put on, the magnet should be simultaneously removed. A few trials will enable a very close estimate to be formed of the deflection which would be obtained if polarisation were not present.

A. E.

London, *February 10th*, 1886.

Telephone Patents.

The splendid contribution to electrical science *given* to the world by Professor Hughes in his masterly inaugural address to the Society of Telegraph Engineers, is quite on a par with Faraday's noble example of 1831, but with this difference, Faraday *gave* his discoveries freely, contenting himself with expressing his confident belief in their ultimate "full development"; but he did not live to see the carrying out of what he was so sure about; Professor Hughes, on the contrary, has lived to see his earlier gift—the discovery of the microphone—utilised to the enhancement of another man's work in a degree that is most marked, for where would have been the value of the Bell telephone had not the microphone come to its aid, as discovered by Professor Hughes? True it is that Edison's patent claim is made to cover it, yet the working instrument of to-day is based upon Hughes's principle rather than Edison's, which, at best, was but a clumsy arrangement, and is now practically abandoned. Yet, for all the benefit—the world wide benefit truly—which his discovery has conferred, and the vast commercial value bestowed, I wonder whether Professor Hughes is to-day one penny the richer? And this brings me to the point noticed by your correspondent "Telephonist," to wit, that if the Bell telephone were upset to-morrow the value to the public would be but little, as *the telephone, used as a transmitter, is a failure;* and that so long as inventors work inside "the combination of a diaphragm with a tension regulator," the Edison claim will be held as good against them.

By the way, Mr. Editor, how would "the combination of a diaphragm with a *current generator*" meet the case? To my provincial mind it looks like a new departure, if it can be accomplished. That well posted telephonic record, Major Barney, when he sees this might perhaps venture an opinion, as I feel sure that, though he is in New York, he yet keeps himself well posted in all matters *re* telephones that appear in the ELECTRICAL REVIEW.

Better instruments will, doubtless, be the outcome of Professor Hughes's more recent discoveries; but in order to break down the monopoly of the firm that will not sell telephones out and out at a reasonable price, efforts must be directed specially to a transmitter free of the Edison. Then the field will be opened, for, with the Glasgow receiver free, the Bell form can be dispensed with.

"Combination."

10*th February*, 1886.

Cable Messages.

Will you please inform me if you are *positive* the article in relation to the "Communication between Europe and this country" has been correctly "set up" by your compositor? May I infer from the above that the only cable working between Europe and America was the Mackay and Bennett Cable? Will you please tell me where Coney Island is located? The article upon the quickest time on record is rather difficult to understand. Will you please tell me where the office is located occupied by the parties to whom that quick cable message was directed? And if it is possible to learn the number of *letters* constituting the message? Is the resistance of the Commercial Cable known? I should like to be informed what current is required to charge the cable sufficient to receive an unmistakable signal? And how many times the circuit had been opened and closed during the transmission of the message, also the length of time occupied in delivering, transacting the business, and getting back with the answer. This is not only the quickest time on record, but the most marvellous feat in the annals of electrical communication, and I believe it is safe to say that no other in the world of the same length will ever do it again.

Bonco.

London, *February 15th*, 1886.

[We must really refer our correspondent to the source from whence we derived our notes, and which is conspicuously mentioned therein.—EDS. ELEC. REV.]

The "Otto" Gas Engine Patents.

We beg to hand you, enclosed, a pamphlet which may be of interest to you. Numerous actions were brought against Messrs. Körting by the holders of the Otto patents in Germany.

In order to get the matter decided once for all, Messrs. Körting brought, as was their right according to German law, an action to declare the Otto patents null and void. This you will see they have succeeded in, the only points remaining to Otto being certain mechanical arrangements as used in his special engine. This decision has been given by the "Reichsgericht,"

or highest court in Germany, from which there is no appeal, consequently all the other actions of Otto fall to the ground.

Korting Bros.

P. M. MULREADY.

London, E.C., *February 11th*, 1886.

[A reprint of the pamphlet to which our correspondent refers may be found in our other columns.—EDS. ELEC. REV.]

Discovery of Electro-Magnetism.

In your issue of December 19th last, Mr. Lutteman devotes over two columns of your valuable space to a refutation of the Romagnosi claim to the discovery of electro-magnetism. This I beg leave to state is, or should be, a work of supererogation, at all events for English readers who have access to my "History of Electric Telegraphy" (Spon, 1884), where the subject is exhaustively treated, pages 256 to 274. Mr. Lutteman might consult these pages with advantage.

If any credit attaches to the settlement of this long-disputed question I claim it for myself, and I appeal to you to endorse my claim, which I feel you will do after a reference to the above-mentioned pages of my book.

Although it is no discredit to Oersted, it should be known that his discovery was the result of a happy accident—see note, page 273 of my "History."

J. J. Fahie.

Teheran, Persia,
January 15th, 1886.

[We think Mr. Fahie's claim is fairly made out.—EDS. ELEC. REV.]

Re F. V. Andersen's Formulæ.

Under problem F in the above very interesting and instructive practical formulæ, which gives the diameter of wire for a shunt which, excited by a given number of volts, has a magnetising power of a given number of ampère turns, Mr. Andersen states:—"This forms part of the common problem: Construct a dynamo to supply C ampères at E volts, running at N revolutions per minute."

Will it be asking too much of Mr. Andersen to help me, and, in all probability, a large number of your readers, by giving us this latter formulæ, and in the same comprehensive manner as his previous ones? By doing so he will greatly oblige

Ohm.

37, Trafalgar Square, Brighton,
February 6th, 1886.

The Franklin Institute Tests of Dynamos.

I beg to enclose you a copy of a letter addressed to me by Prof. Marks, in deference to the request of the President and Board of Managers of the Franklin Institute, from which you will note that the Professor is rather inclined to charge me with personal motives when showing the improbability of the horse-power values obtained by the committee. I have, in justice to myself and also to prevent that the Institute may leave the impossible results on record, addressed a second letter to the Institute, of which I also enclose you a copy, and beg you to give both letters space in your valuable journal, since the discussion relates *not* to theoretical opinions, but to whether the tests made by such an eminent scientific authority are incorrect, and if so, whether or not the report ought to be annulled.

Charles F. Heinrichs.

New York, *February 7th*, 1886.

COMPETITIVE TESTS OF THE EDISON AND WESTON DYNAMO-ELECTRIC MACHINES.

In reply to Mr. Charles F. Heinrichs' criticism of the late dynamo tests at Philadelphia, the Franklin Institute has addressed the following open letter to that gentleman:—

Franklin Institute,
Philadelphia, Pa., *Jan. 20th*, 1886.

Mr. Chas. F. Heinrichs, New York—

Dear Sir,—The President of the Franklin Institute hands me your letter of the 4th inst. for reply. A careful reading of its contents satisfies me that you have not grasped the method of coupling the dynamo to the dynamometer. No belt was used. Fig 7 of the report will make clear at a glance that the end of the dynamo shaft was coupled to the end of the dynamometer shaft.

The tests were competitive, and it was very necessary to eliminate the accidental variations of friction due to errors in stretching belts, in order to judge fairly of so evenly matched and highly finished machines.

There was no friction at all due to pull of belt in any case, and the brushes were always raised.

Whenever the friction of the journals was measured, it was after the machine had been running many hours.

There would be little difficulty in satisfying yourself by actual experiment upon Weston or Edison machines under similar circumstances to those of the test that the friction of the armature bearings is marvellously small.

It would be much better to do so than to take figures from antiquated machines.

Should you, for reasons of your own, desire to make out a less efficiency than that shown in the test, you should add to the power applied sufficient power to meet your views as what *might* be required by the friction due to the pull of the belt on the armature shaft, and by the bending of the belt and for the brush friction, and then this sum should be used to divide the energy of the external circuit. *The phrase "Power applied"* of the report included the friction of the shaft of the armature. Thus, if you insist that the armature friction is 1·337 H.P., you could say for

Weston No. 7 M dynamo $\frac{26{\cdot}34}{29{\cdot}29 + 1{\cdot}337}$ = commercial efficiency,

or $\frac{28{\cdot}47}{29{\cdot}29 + 1{\cdot}337}$ = total efficiency of electrical conversion.

A careful reading of the report, which you criticise with so much apparent confidence of a thorough knowledge of its contents, would have revealed the following paragraph on page 42:—"The friction of the armature and of the dynamometer were obtained and *the latter* subtracted from the power applied to each test."

The committee spent much labour upon the calibration of the Tatham dynamometer, and have every confidence in its results, and believe its error from any cause to be inappreciable, as compared with others.

In deference to the request of the President and Managers of the Franklin Institute, I make reply to your letter, but do not desire to attempt further discussion, when agreement as to premises cannot be reached.

I am, faithfully yours,
WM. D. MARKS.

COMPETITIVE TESTS OF THE EDISON AND WESTON DYNAMO-ELECTRIC MACHINES.

To the President and the Board of Managers of the Franklin Institute.

Gentlemen,—I have noted the contents of the letter which Prof. Marks has addressed to me in the last issue of the *Electrical World*, in deference to your instructions.

In his letter the Professor makes several substantial admissions with which I now can prove conclusively that *all* horse-power measurements made by your committee are incorrect, and have given extreme and enhanced efficiencies to all dynamos tested.

Before, however, substantiating my latter statements, permit me to state that I well know that I address in you an *impartial* scientific authority, and that you will be as much pleased if the tests under discussion can be sustained, as you will be ready to withdraw the report of tests at any time, should it be proven that the results given therein are incorrect. I further know that your committee was composed of gentlemen having great scientific attainments, and of unquestionable integrity; hence, if the tests have produced incorrect results, as I shall presently show, such incorrect results were obtained by inadvertence.

I have in my former letters compared the results obtained by your committee with those obtained by other authorities; but since I note that Prof. Marks objects to the comparisons of his tests with those made two to three years ago, for the reason that those tests were made upon "antiquated dynamos," I shall in the following explanations refer only to the tests made by your committee, and with their report and Prof. Marks's admissions, prove my above-made statements as to the incorrectness of the results.

Firstly. Prof. Marks states in his letter that the committee have every confidence in the results produced by the Tatham dynamometer; thus he maintains that *all* horse-power measurements made by the committee *are correct*. The Professor further admits *indirectly* that the measurements of the items of friction of armatures as made by your committee are incomplete and too small; because the Professor admits *directly* that the brushes were lifted during the tests of the friction of the armatures; *whilst the brushes ought to have been pressed down upon the commutator*, and so the power absorbed by the brushes would have been *duly* accounted for. Hence the phrase "friction of armature" of the report is admitted by the Professor to contain an untrue and too small value and should be taken larger, *without any special desire on my part.*

Further, Tables II., III., IV. of the report contain each two

data of the portioned items of friction of armature obtained from the same armature on different days; but, as can be noted, the two measurements on each of the three tables differ over 50 per cent. from each other, consequently these already portioned items varying over 50 per cent. from each other, may rightly be rejected as untrue, or may be enlarged to a more probable value. I have shown in my letter of the 7th ultimo that when taking a larger and more probable value for the item of friction of armature, and calculating the electrical efficiency of the dynamo with the following well known formula:—

$$\frac{\text{Total electrical efficiency}}{\text{(Power applied)} - \text{(power absorbed by friction of armature)}} = {}^{o}/_{o}$$

more than 100 per cent. electrical return will be obtained. The latter result *simply proves* that the total horse-power measurements made by your committee are equally wrong. Prof. Marks replies to these calculations about as follows:—"If you *insist* that the friction of armature is larger than given by the committee, you may, instead of *deducting* it from the phrase (truly a phrase) 'power applied,' add it to the latter." How can I do that? The Professor reminds me in his letter that the phrase, power applied, means the total power indicated by the transmission dynamometer, minus the friction of the latter; thus the phrase, power applied, contains the whole value of friction of armature, including both the friction of the journals and of the brushes; and since the latter value is omitted by the committee, on calculating the true electrical efficiency of the dynamo, the true value of the friction of armature (including the power absorbed by the brushes) must be *deducted* from the "power applied," which gave over 100 per cent. electrical return. On the other hand, if I please the Professor's view of treating the data of tests, and *add* the true value of friction of armature to the "power applied" of the report, in such case the latter term becomes altogether a phrase, and the new value of the "power applied" becomes much larger than the former; thus again *proving* the incorrectness of the committee's results.

Hence the Professor will note that whenever the item of friction of armature is increased to its due value, all further calculations with the latter will prove conclusively the incorrectness of *all* horse-power measurements made by the committee.

Secondly. In his letter Prof. Marks stated that in "order to judge fairly of so evenly matched and highly finished machines no belts were used, but the dynamo was coupled directly to the transmission dynamometer," and he is satisfied that I have not "grasped" the coupling up. I beg to assure the Professor that I have indeed "grasped" and noted that such coupling will produce an enhanced commercial efficiency. The dynamos tested are to be used with a belt for the reason that no practical engines are made to run at the high speed required, and that the friction of the journals is somewhat greater with a belt than without one, notwithstanding I have not raised that point at all.

I am greatly surprised that the Professor should attempt to explain the great discrepancies, amounting up to 1,000 per cent., between the measurements made by the committee and those by other authorities, with the absence of the belt. The Professor even counts up the *bending* of the belt around the one pulley of the dynamo, yet almost with the same breath speaks confidently of the Tatham dynamometer, but forgets to mention that the large belt of the latter is *bending over six pulleys*, and that such an identical construction must be devoid of the sensitiveness required in "order to test fairly—*to the public*—such evenly matched dynamos."

I admit, gentlemen, that such arguments, though pertinent, do not prove conclusively my statements, and I will proceed to lay before you all the separate items which must be considered under the one heading of friction of armature. Although these considerations will rather increase the length of my address, still it is necessary to go into these details to show conclusively that the values of armature friction as given by your committee are altogether too small and are untrue; further, to prevent the question as to the proper value of the coefficient of friction to be a stumbling block to the final settlement of the latter question.

The friction of armature includes the following:—

I. Friction of journals can be calculated (approximately only) with the formula given in my letter of December 19th, 1885. The coefficient of journal friction is given as ·054 (average); the latter value has been deducted from a great number of experiments made by the three authorities, viz., Mr. T. Webber, U.S.A.; Mr. D. K. Clark, Great Britain; Mr. Morin, France. It will serve well for the speed and weights of the armatures tested by your committee. Prof. Thurston has shown that the theoretical coefficient of journal friction can be much smaller, but all his extremely interesting and valuable experiments were conducted under conditions in which none of the four following factors increasing the coefficient of friction were present.

II. Increase of journal friction, due to the stress of a belt, can be calculated approximately when adding to the weights of the armature and shaft the resultant stress of the belt in pounds.

III. Increase of journal friction produced by the centrifugal force resulting from a slight displacement of the centre of gyration of the armature from the centre of the shaft can be noted in most armatures, since the latter are built up from a great number of pieces of metal and insulating material, and with the surrounding conductors will never be found exactly concentric with the shaft.

IV. An increase of the coefficient of journal friction will take place by the vibrations which are always set up by the rapidly rotating armatures.

V. The resistance of the air will absorb an estimateable power since the armatures are always slightly uneven and rotate closely within the partially open field magnets at a rate of from 40 to 60 miles an hour.

VI. Power absorbed by the friction of the brushes upon the commutator is considerably larger in dynamos giving out large currents, such as tested by your committee, in which several sets of brushes are sometimes employed.

The values of none of the five first specified items can be calculated exactly; since the coefficient of journal friction *varies* with the number of revolutions and the weight of the armatures (pressure); as known, the coefficient is very great at the start, but decreases greatly with the increase of the speed up to a certain point after which the coefficient again increases rapidly, until abrasion of the journal and bearings takes place.

One test recently made by M. Marcel Deprez with a heavy armature is mentioned by Prof. Thurston,* which I shall quote, reversing the order in which it is given: "The coefficient was very great at the start and fell to ·005 at 120 revolutions per minute, and remained the same until 145 revolutions, after which it rose to ·025 at 550 revolutions;" and must evidently have increased greatly at 1,000 or more revolutions, the speeds of the dynamos tested by your committee.

All beforegoing proves that the calculations of the probable values of the power absorbed by the friction of the armature tested by your committee, as given in my letter of the 19th December, 1885, are very fair to your committee. The calculations of the friction of the journals and of the brushes were made separately, and showed that the mere journal friction calculated was much larger than given by the committee; and with the brush friction added, the total items of armature frictions were many times larger than those given by the committee: thus there can be no further doubt that the results given by the committee are altogether incorrect.

The Professor cannot further maintain that I only *insist* for reasons of my own upon a larger value of friction of armature, and I trust he will now admit that, notwithstanding the friction of the armature is "*marvellously*" *small* (when the brushes are lifted), the items given by the committee are from 300 to 1,000 per cent. too small.

Thirdly. The incorrectness of the tests made by your committee is still further proven by the following considerations relating to the transmission dynamometer used. The latter was calibrated with a load of about 40 horse-power and 700 revolutions per minute, and it was relied on for the power measurements of all other loads and speeds, which I shall show to be incorrect, and has led to the incorrect results of the measurements of the "power applied" to the dynamo.

All which has been brought forward by me when considering the variableness of the coefficient of journal friction applied to the six shafts of the Tatham dynamometer (also to the shaft and transmission pulley of every other dynamometer). The coefficient of journal friction varies greatly with the different loads and speeds, consequently the calibration of the latter of one load and speed cannot serve for another load and speed. *The dynamometer must be calibrated for every different load and speed.*

The committee have not calibrated their dynamometer for any *electrical* load and speed actually used during the tests, consequently all results must be rejected.

All the before-given explanations and considerations *prove conclusively* and *finally* that all horse-power measurements made by your committee are incorrect and must be rejected and annulled.

Summing up: you will note, Gentlemen, the following:—

1. That the horse-power measurements made by your committee of the friction of armature are admitted to be untrue, only a portion of each item was measured, and of the latter, those items which were measured twice, differ over 50 per cent. from each other. Thus the whole measurements of these items must be rejected.

2. That the values of the friction of armature given by your committee, are about from 300 to 1,000 per cent. too small, has been shown by me with all tests previously made; further, with the calculations made of this item, and the physical conditions which are pertaining to the friction of armatures. All this has proven that the already portioned values of friction of armatures as given by your committee are altogether too small.

3. That whenever one accepts the true or a probable value of the friction of armatures, and then calculates the electrical efficiency of the dynamo, the impossible result obtained proves conclusively that all horse-power measurements made by your committee are also incorrect.

4. The committee not having calibrated the dynamometer with any one of the electrical loads actually used during the tests, prevents the acceptance of any of the results obtained with that dynamometer; whatever else may be said as to the merits of the latter.

Trusting that you will, Gentlemen, now consider the advisability of withdrawal or annullment of the report of tests issued by your authority,

I beg to remain, Gentlemen,

Yours faithfully,

CHARLES F. HEINRICHS.

New York, *Feb. 2nd*, 1886.

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* "Friction and Lost Work," &c. By Prof. Thurston. New York, 1885.